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SustainIT: A Collaborative Serious Game for Sustainability and IT

Master's thesis in Master of Science in Informatics

Supervisor: Monica Divitini

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Abstract

The challenges posed by sustainability are of immediate global concern and the field of information technology (IT) has a critical role in supporting sustainable development. However, there are also various ways in which IT contributes to the issues. Despite the ever-growing need for IT professionals qualified to take on these challenges, education in sustainability and IT has so far been lacking. IT students, who are the future of the industry, need an understanding of the far-reaching implications of IT, and to acknowledge their responsibility for the systems they create, to actively contribute to positive change.

To address this need, this thesis explores how collaborative serious games can be utilized as a tool to develop IT students' knowledge and perception of sustainability and its connection with IT. Previous research has found the use of games to teach sustainability promising, and in this thesis, a 3D collaborative serious game featuring promising engagement elements and learning elements is presented. This study further contributes to the area of educational games teaching sustainability and IT. The primary learning goals of the game were to promote systems thinking, an understanding of the connection between sustainability and IT, and challenge existing perceptions. Focus has been put on finding effective game elements to promote learning and engagement, to support these learning outcomes. The study involves the design, multiple evaluations, and final test of the implemented prototype of SustainIT: a collaborative serious game where the players communicate across the past and future to make more sustainable decisions for an IT company. The prototype underwent multiple evaluations with experts and the target group at different stages of development to strengthen the concept and use of game elements.

The results presented in this research indicate that collaborative serious games have the potential to facilitate learning, in the effort to develop IT students' knowledge in sustainability and IT. These findings can inform the design and development of future serious games aimed at cultivating the understanding of the various impacts of IT on sustainability. The game concept can also be extended for use in interdisciplinary contexts since the broad influence of digitalization across society makes this knowledge valuable and relevant for all.

The game can be downloaded for Windows, Apple Silicone Mac, and Intel-based Mac from <https://benedihm.itch.io/sustainit>.

Sammendrag

Bærekraftsutfordringene er av umiddelbar global bekymring, og informasjonsteknologi (IT) har en avgjørende rolle i å støtte bærekraftig utvikling. Samtidig bidrar også IT til problemene. Til tross for det stadig økende behovet for IT-fagfolk som er kvalifisert til å ta tak i disse utfordringene, har utdanning i bærekraft og IT så langt vært mangelfull. IT-studenter, som er fremtiden til bransjen, trenger en forståelse av de brede konsekvensene av IT-systemer, og må anerkjenne ansvaret de har for systemene de skaper, for å aktivt kunne bidra til positiv endring.

For å møte dette behovet, utforsker denne oppgaven hvordan seriøse samarbeidsspill kan brukes som et verktøy for å utvikle IT-studenters kunnskap og oppfatning av bærekraft og dets sammenheng med IT. Tidligere forskning har funnet at bruken av spill for å lære bort bærekraft er lovende, og i denne oppgaven presenteres et 3D seriøst samarbeidsspill med lovende engasjementslementer og læringslementer. Denne studien bidrar videre til pedagogiske spill som lærer bort bærekraft og IT. De primære læringsmålene med spillet var å fremme systemtenkning, en forståelse av sammenhengen mellom bærekraft og IT, og utfordre eksisterende oppfatninger. Fokuset har vært å finne effektive spillelementer for å fremme læring og engasjement for å støtte disse læringsutbyttene. Studien involverer design, flere evalueringer og en siste test av den implementerte prototypen av SustainIT: et seriøst samarbeidsspill der spillerne kommuniserer på tvers av fortid og fremtid for å ta mer bærekraftige beslutninger for et IT-selskap. Prototypen gjennomgikk flere evalueringer med eksperter og målgruppen under ulike stadier av utviklingen for å styrke konseptet og bruken av spillelementer.

Resultatene som presenteres i denne forskningen indikerer at samarbeidende seriøse spill har potensialet til å legge til rette for læring, i arbeidet med å utvikle IT-studenters kunnskap i bærekraft og IT. Disse funnene kan informere fremtidig design og utvikling av seriøse spill som tar sikte på å dyrke forståelsen av de ulike påvirkningene IT har på bærekraft. Spillkonseptet kan også utvides til bruk i tverrfaglige sammenhenger, da den brede innflytelsen av digitalisering på tvers av samfunnet gjør denne kunnskapen verdifull og relevant for alle.

Spillet kan lastes ned for Windows, Apple Silicone Mac og Intel-basert Mac fra <https://benedihm.itch.io/sustainit>.

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Acronyms

IT Information Technology

ICT Information and Communication Technology

SG Serious Game

SDG Sustainable development goals

DP Design Patterns

SusAF Sustainability Awareness Framework

SusAD Sustainability Awareness Diagram

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Benedicte H. Myrvoll
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Chapter 1

Introduction

1.1 Motivation

Sustainability and climate change are among the biggest challenges to be addressed in today's society, and the field of information technology (IT) has a crucial role in supporting sustainable development and addressing climate change [1], [2] [3]. On the other hand, IT is also a contributor to the problem. Studies argue that IT systems can have negative impacts on sustainability and that there needs to be put more effort into understanding these effects and how to reduce them [2], [4], [5], [6], [7]. It is therefore critical to teach future IT professionals about sustainability and the impacts of IT and give them an understanding of how IT systems may have far-reaching consequences outside of the system itself. They also need to reflect on their role as IT practitioners and understand their responsibility for the long-term impacts of the systems they develop. Becker et. al. puts it well: "If we don't take sustainability into account when designing, no matter in which domain and for what purpose, we miss the opportunity to cause positive change" [2, p. 473].

Despite this, sustainability as a topic has been slow in its introduction in computation education [1]. There have been identified barriers that ultimately hinder educators from including sustainability in their courses, such as a lack of relevant resources and literature, and a lack of will to address these topics in the computing curriculum due to an understanding of sustainability as irrelevant or less important [1]. Previous efforts have been made to learn more about how sustainability can be incorporated into the computing curriculum, and what IT students specifically should learn within sustainability. Some findings emphasize that IT students learn systems thinking [1], [8]. Easterbrook [8] argues that the computer science curriculum has put too much focus on computational thinking and that systems thinking can help students gain a greater understanding of sustainability. Furthermore, previous research recommends that IT practitioners learn about the connection between IT and sustainability, by understanding that IT systems have effects across five different sustainability dimensions that can be immediate, enabling, and systemic [2], [9] [10]. The findings also agree that it's important to challenge the misperception of sustainability as something that does not concern computing and move students toward recognizing their responsibility as IT practitioners to address these issues [1], [2], [3].

Serious games can be a powerful tool to promote engagement and learning outcomes. In [11], the findings indicated that games support cognitive, skill-based, and affective outcomes. Previous research has also found that using games to learn sustainability has a positive effect on both learning outcomes and engagement [12], [13]. Furthermore, the use of collaboration in serious games has been shown to promote sociability, knowledge construction, and positive game experiences [14], although there is a demand for more research in this area [15].

Based on this, the thesis will focus on creating a collaborative game for learning about sustainability and IT. The goal of the game will be to support learning systems thinking and sustainability for students in IT and to challenge their perception of these concepts. The study will also discuss how game elements can support these learning goals and promote engagement. The results of this research will contribute to the area of collaborative serious games on sustainability and IT.

1.2 Context

This master's thesis has been done in collaboration with the Department of Computer Science at the Norwegian University of Science and Technology. The work builds upon the work done in the preparatory project by Myrvoll in [16], where sustainability in IT was explored to understand the state of the fields in this domain, the state of the education in these topics, and the potential of a collaborative educational game to support teaching IT and sustainability to IT students. The contents of this thesis have been written under the supervision and guidance of Professor Monica Divitini.

1.3 Research Questions

This research aims to explore how a serious game that increases knowledge about IT and sustainability can be designed. In the preparatory project [16], the findings of the literature revealed that even though the field of IT has been shown to both support and harm sustainability, computing education has been slow to implement sustainability topics into the curriculum. It was also found that there is potential in using serious games to teach sustainability, and that collaboration in games can further promote engagement, sociability, and shared knowledge construction. This research will therefore cover the design, development, and evaluations of a collaborative serious game for sustainability and IT, through the initial conceptualization to the implementation of a working prototype. The main research question goes as follows:

RQ1: How can a collaborative serious game be designed to develop knowledge about IT and sustainability among IT students, and challenge their perception of the topic?

To answer this research question, a set of secondary research questions have been created.

RQ1.1: How can learning elements be used in a collaborative serious game to teach sustainability and IT, and challenge students' perceptions?

The game should help develop IT students' knowledge about the connection between IT and sustainability. To make sure the students get the intended learning outcomes from playing the game, the game activities must therefore align with the learning objectives. The content of the game must also include relevant cases that can illustrate the ways that IT and sustainability are connected. Furthermore, to create an engaging experience that has an impact on IT students and their view and understanding of IT and sustainability, the game elements included in the game must be carefully considered based on their ability to evoke emotions and reflection within the player, to move the students toward understanding the importance of addressing sustainability in IT.

RQ1.2: What kind of game elements can be used in a collaborative serious game to motivate and engage students in learning about sustainability and IT?

One of the most compelling reasons for using serious games in education is their ability to motivate and engage the students. An important part of this study is therefore to explore what types of game elements can be motivating and engaging, as well as promote learning outcomes in the context of a collaborative serious game for IT students learning about IT and sustainability.

1.4 Research Methods

This research aims to design a game that can develop IT students' knowledge and perceptions about sustainability and IT, and to reach this goal the Design Science Research method has been chosen as methodology [17]. The process is characterized by the creation and evaluation of artifacts within specific domains through three cycles. The cycles are the *Relevance*, *Design*, and *Rigor cycle*, as illustrated in Figure 1.1. Requirements and acceptance criteria are found in the *Relevance Cycle*, which guides the final evaluation of the results. Through the *Rigor Cycle*, the knowledge base of the artifact is expanded upon by adding scientific foundations, experience, and expertise which confirms the innovative potential of the artifact. Finally, in the *Design Cycle*, the artifact of the project is developed and evaluated through iterations.

The qualitative data obtained in this study have been collected through interviews, a questionnaire, and observation. An application was submitted to SIKT to receive approval on the data collection methods. The approval can be found in Appendix A, and the information letters distributed to the participants can be found in Appendix B. An overview of the research activities conducted in this project can be found in Figure 1.2.

1.5 Results

The results of this research contribute to the field of collaborative serious games for sustainability and IT in the following ways:

- SustainIT: A collaborative serious game to develop IT students' knowledge about sustainability and IT.

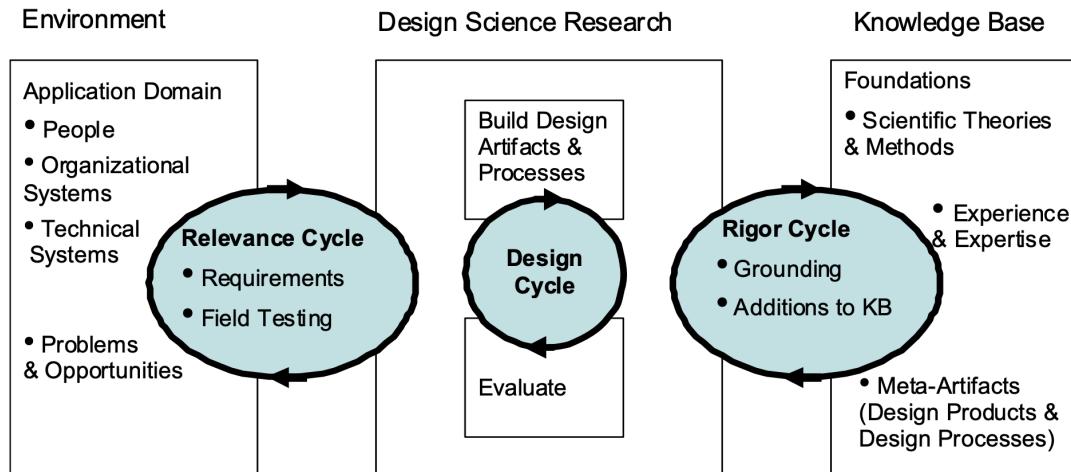


Figure 1.1: The Design Science Research cycles Hefner, 2007

- Additional insights into sustainability education in IT.
- Additional insights into SGs as educational tools for sustainability
- A discussion of the potential of collaborative serious games for teaching IT and sustainability.
- A discussion of learning goals in a game that aims to develop knowledge in sustainability and IT.
- A discussion of game elements that support learning and engagement in a collaborative game for sustainability and IT.

The results of this thesis have been collected through a review of related work, evaluations of the game concept with a game expert, sustainability expert, and IT student, and evaluations and testing of the implemented prototype with an expert in sustainability and IT and the target group. The literature review resulted in a collection of game elements and design principles (DPs) that have inspired the final game concept chosen for further design, evaluation, and testing in this study. The work done in this project has resulted in the game design of the collaborative serious game SustainIT. The findings, therefore, provide further insight into the design of collaborative games for sustainability and IT, which may be utilized in future research in this area.

1.6 Outline

The master thesis consists of a total of 11 chapters. In Chapter 2 findings from the preparatory project which serves as the foundation for this master's thesis will be summarized. Chapter 3 presents existing literature on teaching sustainability and IT, sustainability and IT games, and existing research on game elements and design guidelines for serious games that can be utilized in the game design and development in this research. Chapter 4 features three different game concepts with a discussion on the final choice of

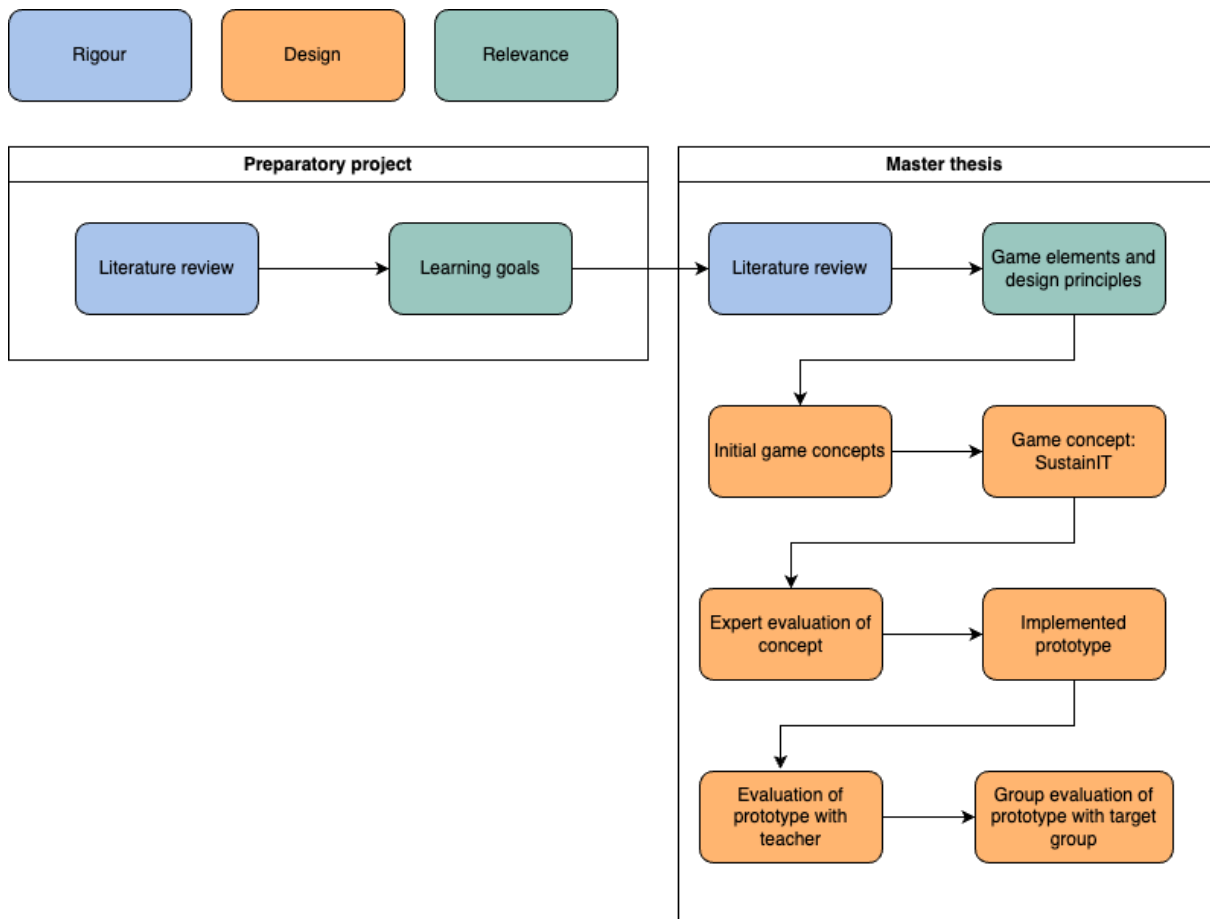


Figure 1.2: Overview of preparatory project and master thesis

concept for the study. The chosen game concept, SustainIT, is further elaborated upon in Chapter 5. Chapter 6, 8, and 9 details the evaluations of the game at different stages of the design process. The implementation of the game prototype is described in Chapter 7. Finally, the results of this study are discussed in Chapter 10, and the conclusion can be found in Chapter 11.

Chapter 2

Problem Elaboration

In this chapter, the problem definition for this master thesis will be described. The research will further build upon the work done in the preparatory project written by the author [16].

2.1 Summary of Preparatory Project

In the preparatory project, the body of knowledge within sustainability and IT was explored, to learn more about the impact of IT on sustainability and the different approaches and fields on the topic that exist. [16]. A summary of these findings will be presented in this section.

IT can support the transition to a more sustainable world with innovative solutions and digitalization [18], [7]. However, there are also several ways in which IT is part of the problem. In [5], they argue that Information and Communication Technology (ICT) could contribute to between 2.1% and 3.9% of the global greenhouse gas emissions. Moreover, Lange, Poul, and Santarius [6] found that rather than reducing energy usage and demand, ICT increases it. There are also impacts on the socio-economic and natural environment due to the influence of software systems on users' behavior and habits [10].

Several fields study the impact of IT on sustainability, and they all look at the subject from different perspectives and suggest different ways to tackle the issues [16]. Previous research on sustainability and IT has found that IT can contribute both positively and negatively towards sustainable development [9],[10], [7]. These effects can be seen in five interrelated dimensions: *individual*, *social*, *environmental*, *economic*, and *technical*, and be distinguished into three orders of effects: *immediate*, *enabling* and *systemic* [9], [10]. A collection of principles to guide practitioners within software development and research have been detailed in The Karlskrona Manifesto for sustainability design [2]. Here, they emphasize the importance of systemic thinking, the five dimensions of sustainability, and the three orders of effects, among other principles to adopt a sustainable practice within software engineering.

2.1.1 Sustainability Education in IT

Research on the incorporation of sustainability in IT education was investigated in the preparatory project, to learn about the state of sustainability education in IT, and how this has been addressed in the past [16]. The existing body of knowledge revealed that there have been some initiatives to include sustainability in the curriculum of higher education in IT. However, the general observation is that computing education has been slow in comparison to other disciplines, which can be attributed to the existence of several barriers and challenges that hinder IT educators. There is therefore still a need for more work to be done in this area. In [1], experts described the current situation of sustainability education in computing as "dire", "immature" and "awfully bad". Two compelling challenges were also identified in their research: The difficulty with finding relevant research and the scarce amount of literature on teaching these topics in the computing curriculum, as well as the attitude towards sustainability as something that does not concern computing, and that other issues should take the front seat in the curriculum. The overall consensus was that systems thinking is important and that students should be educated on the totality of a system and where ICT fits into the picture.

2.1.2 Implications for Game Design

The preparatory project also explored the potential for creating a collaborative serious game to teach sustainability and IT [16]. Game-based learning has been shown to support engagement and learning outcomes. Furthermore, it has been found that collaborative games can promote engagement, social presence, and positive game experiences [14]. Research on sustainability games was inspected and four collaborative sustainability games were reviewed to learn more about how such games can be made. The inspected work by Stanitsas et al. [13] revealed that there have been made several sustainability games for many different fields in the past 15 years. Additionally, the research by de Salas et al. [19] emphasized the importance of thoroughly reporting design choices made when creating serious games for sustainability, as this has been lacking in the past. The reviewed sustainability games were all collaborative, and the design, learning goals, and evaluation were looked at and compared. The review revealed a potential for using simulation games to teach sustainability and IT, although it also showed that successful collaborative sustainability games can be implemented in a range of game genres.

2.2 Learning Goals

The primary goal of the game is to develop IT students' knowledge about sustainability and IT and to challenge any misperceptions they may have on this topic. Based on the findings of the literary research done in the preparatory project, a set of learning goals have been decided upon for the game, which will be presented in this section.

2.2.1 Systems Thinking

Experts agree that computing students should learn systems thinking to get a better understanding of sustainability [1]. [8] argues that "a different kind of thinking, taking into account the emergent properties of complex systems, and the ways in which the dynamics of social systems shape our use of technology within them" is a requirement for understanding and reasoning about sustainability. The first principle of *The Karlskrona Manifesto* [2] is also to acknowledge that sustainability is systemic. Systems thinking has been defined in several different ways in the literature, and its meaning is unclear [20]. Nevertheless, in this study the description by Voulvoulis et al. is helpful:

Systems thinking is about understanding the underlying drivers, interactions, and conditions that influence our decisions, helping us articulate problems in new and different ways and expand our boundaries of time and space to avoid or reduce potential unintended consequences. It is the intentional process of understanding how to alter the components and structures that cause a system to behave in a certain way and identifying places where relatively small actions can lead to potentially transformative systemic changes [21, p.5].

A learning goal for the game is, therefore, to give IT students a better understanding of how IT systems are part of a bigger complex context, and that their decisions may have far-reaching unintended consequences outside of the system itself. A part of this learning goal is to move away from thinking about sustainability as a problem to be solved, and toward an understanding of sustainability as a wicked problem; a challenge to be addressed [2].

2.2.2 The Impact of IT on Sustainability

Another learning goal of the game is to learn about the ways IT artifacts can impact sustainability, and that there are both positive and negative effects. The Karlskrona Manifesto [2] underlines that designers of software technology are responsible for the long-term impacts of the technology they are designing and that they need to address the potential harm of these effects. Students should therefore understand the different ways in which IT can harm sustainability, and how these effects not only are immediate but can happen in the long term. The five dimensions of sustainability and the three orders of effect as described in [9] and [10] can be a helpful basis for giving an understanding of how IT has impacts across multiple dimensions and timescales. These are further described in Table 2.1 and 2.2.

2.2.3 Perceptions of Sustainability in IT

In [1], it was revealed that one barrier to the introduction of sustainability in the computation curriculum is the understanding of sustainability as something that does not concern computing education and that other problems must take priority. Experts also reported that there were climate deniers among the students and teachers, a disinterest in learning about sustainability, and few students applying to the elective courses in the subject. In [22, p. 9] they argue that "we need to engage the students in such a way

Sustainability dimension	Description
The individual dimension	”Covers individual freedom and agency (the ability to act in an environment), human dignity, and fulfillment. It includes individuals’ ability to thrive, exercise their rights, and develop freely.”
The social dimension	”Covers relationships between individuals and groups. For example, it covers the structures of mutual trust and communication in a social system and the balance between conflicting interests.”
The economic dimension	”Covers financial aspects and business value. It includes capital growth and liquidity, investment questions, and financial operations.”
The technical dimension	”Covers the ability to maintain and evolve artificial systems (such as software) over time. It refers to maintenance and evolution, resilience, and the ease of system transitions.”
The environmental dimension	”Covers the use and stewardship of natural resources. It includes questions ranging from immediate waste production and energy consumption to the balance of local ecosystems and climate change concerns.”

Table 2.1: The five dimensions of sustainability as described by Becker et al., 2016

that it leaves them with a lasting impression and a critical mindset that they can make use of both throughout the engineering education and later, in their professional lives”. It is not enough to put efforts into developing knowledge about sustainability among IT students if they do not feel compelled to learn and apply the knowledge in their practice. A goal of the game should therefore also be to challenge their perceptions toward the issue and their role as IT practitioners. Students should have an understanding that all choices they make within an IT project can have far-reaching consequences for sustainability outside of the system itself. Students should also understand the responsibility they have as practitioners in IT to address these issues in their work.

2.3 Target Audience

The target audience of the game will be students that are studying IT at university. The findings of the literary research done in [16] indicated that there is still more to do when

Order of effect	Description
Immediate effects	”Are the direct effects of the production, use, and disposal of software systems. This includes the immediate benefit of system features and the full life-cycle impacts, such as a life-cycle assessment (LCA) would include. An LCA evaluates the environmental impact of a product’s life from the extraction of raw materials to its disposal or recycling.”
Enabling effects	”Arise from a system’s application over time. This includes not only opportunities to consume more (or fewer) resources but also other changes induced by system use.”
Systemic effects	”Represent “persistent changes observable at the macro level. Structures emerge from the entirety of actions at the micro level and, in turn, influence these actions.” Ongoing use of a new software system can lead to shifts in capital accumulation; drive changes in social norms, policies, and laws; and alter our relationship with the natural world.”

Table 2.2: The orders of effect as described in Becker et al., 2016

it comes to introducing sustainability in higher education in IT. They also highlighted the importance of teaching students these skills, to fulfill the needs of the industry and society as a whole. IT can have potentially harmful and far-reaching consequences for sustainability, and students in IT must understand these impacts to move toward creating more sustainable IT systems in the future. The perception of sustainability as something that does not concern the field of IT must also be challenged, to move toward a recognition of the responsibility IT practitioners have to address these issues. A serious game can therefore potentially be a great tool to engage and teach IT students about sustainability and IT.

Primary Learning goal	Secondary Learning Goal
Learn systems thinking	Understanding that IT systems are part of a bigger complex context, and may have far-reaching unintended consequences outside of the system itself. Moving toward understanding sustainability as a wicked problem, a challenge to be addressed rather than a problem to solve
Gain insight into how IT and sustainability are connected, and that IT systems not only have immediate impacts on sustainability but there are also long-term effects	Learning that IT can have an impact on sustainability across five different dimensions: <i>environmental</i> , <i>individual</i> , <i>economical</i> , <i>technical</i> , and <i>social</i> as described in Table 2.1, and learning that IT can have <i>immediate</i> , <i>enabling</i> and <i>systemic</i> effects as described in Table 2.2
Challenging the perception of IT and sustainability	Understanding the importance of considering sustainability in IT systems, and the responsibility IT practitioners have for the long-term impacts of systems they develop

Table 2.3: Learning Goals

Chapter 3

State of the Art

In this chapter, the goal is to explore the body of knowledge on teaching systems thinking and sustainability, as well as the literature on game elements and design guidelines in serious games. The aim is to identify learning elements and engaging elements that can be relevant to create a collaborative game that teaches IT and sustainability to IT students, in an effort to answer **RQ1.1** and **RQ1.2**.

Section 3.1 looks at previous research into teaching sustainability to IT students, focusing on the learning goals established in Section 2.2. Section 3.2 examines previous educational games in sustainability and IT, in an effort to position the research being done in this thesis. Section 3.3 explores game elements and design guidelines that can be relevant to this study. Finally, Section 3.4 presents a discussion of the findings which will be used to guide the design and development of the game concept in this thesis.

3.1 Recommendations for Teaching Sustainability and IT

As previously stated in Section 2.1.1, a big challenge in introducing sustainability to the computing curriculum is the lack of literature on teaching such subjects. Nevertheless, this section will shine light on some of the recommendations that have been found, to inform the learning elements of the game.

3.1.1 Systems Thinking and Sustainability

In the report by Pollock et al. [1], interviews with experts revealed several recommendations for teaching about sustainability and IT. Students "should be critical, reflective, taking responsibility, thinking holistically, and not just comply with top-level orders." [1, p.12]. Some of the advice was that students should learn to ask questions about the purpose of what they are making and the problems they are solving and to identify where they can use these skills. They should engage in debates and values, and learn to see problems from different perspectives. Furthermore, they should learn to analyze the impact of systems and understand the totality of such systems. The experts also pointed out the importance of being open about mistakes, and that "education needs

to handle failure in more constructive ways” to prepare students to become sustainable practitioners. [1, p. 12]

Easterbrook [8], argues that systems thinking is both a challenging concept to teach and learn and that it has been considered too abstract and complicated to embed in the existing higher education curriculum. To deal with these issues, he introduced a collection of games in the classroom from *The Systems Thinking Playbook* [23], to give the students a hands-on experience with systems thinking. He found that the games worked well with different students and elicited a positive response from them, although further research was needed to learn more about the effectiveness of using such games.

In [24], an approach to help software engineers understand the complexity of sustainability problems and how software can bring about change in the wider system is discussed. They suggest the use of leverage points (LP) as an analysis tool to facilitate the identification of ways to effectively change a system at different levels. Meadows define leverage points as ”places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift in one thing can produce big changes in everything” [7, p. 1]. Penzenstadler et. al. continue to argue that ”a holistic analysis of the systems in which our software will be deployed provides an important starting point for understanding the set of LPs we have access to, and how to deploy them” [24, p. 29].

[4] describes a question-based framework called *Sustainability Awareness Framework (SusAF)* that can be used to raise students’ awareness of how software systems can impact sustainability. The framework consists of the *Sustainability Awareness Diagram* which helps visualize the five dimensions of sustainability and the three orders of effect, and five question sets that aid the process of filling out the diagram. They argue that it is both simple and accessible, which can allow students to use it without background knowledge. An example use of the *Sustainability Awareness Diagram* with AirBnB as inspiration can be found in Figure 3.1.

3.1.2 Perceptions of Sustainability and IT

To ensure that the students not only learn more about sustainability in IT but also motivate them to change their practice accordingly, the game must confront existing perceptions of sustainability in IT. In [3, p. 38] they establish that ”it is crucial to find ways to connect and bridge the distance between students’ perceptions of their own profession and sustainability as a topic”. In [22], the same authors present a framework that consists of three dimensions: *Deliver facts vs. discuss values*, ”*vanilla sustainability*” vs. ”*doomsday sustainability*”, and *ICT and media vs. personal and societal sustainability*, which was created through an effort to engage and change students perceptions of sustainability. *Deliver facts vs. discuss values* is about not only conveying the facts of sustainability and its issues but also bringing in discussions on values and creating a safe space for both students and teachers to open up about their uncertainties and fears. ”*vanilla sustainability*” vs. ”*doomsday sustainability*” relates to the difference between talking about sustainability and climate change as something that eventually will be solved through innovations and mitigation strategies, and talking about sustainability

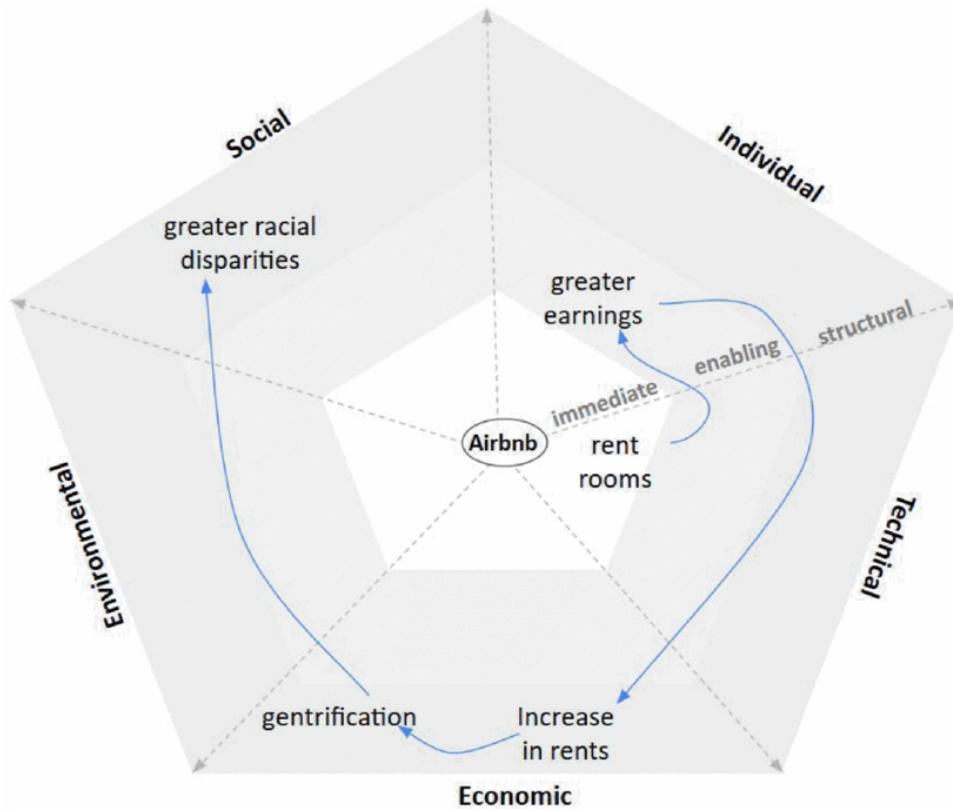


Figure 3.1: A simplified SusAD of the immediate, enabling, and structural effects of Airbnb in the five sustainability dimensions Duboc et. al, 2019.

as something that is already unobtainable, and that the way forward is learning how to adapt with the coming changes. Finally, *ICT and media vs. personal and societal sustainability* is about balancing the content of a course between ICT and sustainability topics, vs topics around sustainability outside of ICT. By using this framework in a sustainability course, the students changed their views from having doubts about climate change to being more concerned about the issue.

A study by Hilty and Huber [25] looked at what content students in ICT-related studies were most motivated by in a course about sustainability, and thus increased their engagement with the topic. They found five thematic clusters with great potential: *ICT impacts on sustainability*, *Recycling of ICT hardware*, *ICT as an enabler*, *Resource consumption* and *Rebound effects*.

3.2 Serious Games on IT and Sustainability

In this section, literature on sustainability serious games will be presented with the aim to position the work of this thesis, as well as learning more about what has been done in this area in the past.

3.2.1 Serious Games on Sustainability

As described in 2.1.2, game-based learning can promote engagement and learning outcomes, and these effects have also been shown in serious games on sustainability. However, in [13], they argue that only a small amount of serious games on sustainability promote a holistic view, and most tend to focus on only a few educational aspects of the sustainability dimensions. They, therefore, call for more studies that look for features that can support such learning. They also propose that researchers developing serious games for sustainability in the future, use 3D graphics to make the experience more realistic and to increase the intensity of the social interaction to further support the social dimension of sustainability.

3.2.2 Sustainability Games in IT

A few studies utilizing educational games to teach sustainability in IT have been found in the literature. In one study a mobile application game was created where sustainable development was combined with computer science knowledge [26]. The goal was to learn to solve algorithmic problems using JavaScript while learning about environmental issues and increasing the motivation to protect the environment. The study yielded positive results for both objectives and showed that teaching environmental topics and computer science together through game-based learning is achievable. Some studies have utilized board games to teach sustainability to computer science and Media Technology engineering students [27],[28]. Leifler et al. [27] held seminars where the students played the board games Dilemma and Fish Banks, which tells about the interrelated dimensions of sustainability and the effects of IT. Pargman, Hedin, and Eriksson [28] introduced the board game Gasuco in their course on *Sustainability and Media Technology*, where two of the objectives were to both make students more interested in and motivated for sustainability, as well as increasing their knowledge about sustainability. The results for both studies were promising. In another study by E. Eriksson et al. [29], they were inspired by Easterbrook and introduced systems thinking games into a course on sustainability and media technology. The games were chosen from the ones presented in *The Systems Thinking Playbook for Climate Change* [30], and the activities were deemed valuable as a teaching tool although there were some issues raised with the implementation.

Research has also been done on educational games on sustainability in engineering courses outside of IT. The study by [12] reviews different games applied to engineering studies at the Royal Institute of Technology (Sweden) and the University of Cambridge (UK). In another study by G. W. Scurati et al. [31], they created a serious game for raising awareness of sustainability for aerospace engineering students.

3.3 Game Elements

Motivation and engagement are two of the main factors that make serious games such a powerful tool for learning. Laine and Lindeberg define engagement as "the level of involvement that the learner exhibits toward the learning process", and motivation as "the reason for the learner to become and remain engaged in a learning activity" [32, p.

1]. Both are therefore important elements that ensure a continued desire to participate in learning. On the other hand, gamification in the classroom has been shown to not always have the desired effects, and can potentially harm the motivation and learning outcomes [33]. Creating an educational game that is both motivating and engaging is a challenging endeavor, and to harness the potential it is crucial to carefully apply game motivators and mechanics that are appropriate for the specific context [32]. Seeing that documentation of the design process has been found to be inadequate in previous studies within SGs on sustainability [19], there is further motivation to make mindful design choices and describe the design process in this study.

There have been conducted multiple literary reviews that aim to find engaging game and learning elements and develop a set of guidelines that can help researchers in their game design process [32], [15], [34], [35]. This section will therefore look at some of the existing literature that addresses game elements and design guidelines in serious games, to gather relevant guidelines, game elements, and learning elements for this study.

3.3.1 Engaging and Motivating Game Elements

Lain and Lindberg [32] conducted a systematic review where they created a taxonomy of 56 game motivators and a taxonomy of 54 educational game design principles that can support the creation of engaging educational games. They argue that the use of DPs won't necessarily equal a motivating game with great learning outcomes and that it is up to the designers to follow them in a way that makes sense for the educational game design problem that is being addressed. The motivators were divided into 14 classes which consists of *Challenge*, *Competence*, *Competition*, *Control*, *Curiosity*, *Emotions*, *Fantasy*, *Feedback*, *Immersion*, *Novelty*, *Rules and Goals*, *Real World Relation*, *Social interaction* and *Usefulness*. The DPs are divided into 13 classes which are *Challenge*, *Control*, *Creativity*, *Exploration*, *Fairness*, *Feedback*, *Goals*, *Learning*, *Profile and Ownership*, *Relevance and Relatedness*, *Resources and Economy*, *Social Play*, and *Storytelling and fantasy*, which are connected to the motivator classes. The classes of design principles will be further described below.

Challenge

Challenge is a common game motivator that is supported by creating tasks that fit the skill level of the players. What is deemed challenging depends on the player, but it's important that the tasks are neither too easy nor too difficult, and that the players are allowed enough time to solve them. If a game is too challenging, it can lead to discouragement and less engagement.

Control

Control relates to both the ability of the player to make choices in the game, and the ways the player can interact with the game through mechanics.

Creativity

This class relates to allowing the players to self-express and use their creativity. It is also about giving the player more influence over the gameplay and creating challenges that can be solved in multiple ways.

Exploration

Exploration can stimulate a sense of control and support curiosity. It can also support the real-world context of the game. The class involves allowing the players to explore the game world freely and offering several paths and options to reach the goals.

Fairness

Ensuring that all players can enjoy the game equally. It includes DPs such as preventing cheating and making sure all players may succeed in the game regardless of experience.

Feedback

This class relates to the way the game responds to player input. Providing immediate, positive, and useful feedback, and delivering it in a clear manner. Offering instructions or tutorials to help the player understand how to play and proceed in the game. Connects to control and competence motivators.

Goals

Goals are a vital part of a game, and the DPs for this class support the goal, challenge, rules, competence, and feedback motivator. This involves establishing clear, meaningful, and achievable goals, and making them build upon one another.

Learning

This class presents DPs that can support learning, which contributes to motivation through usefulness and competence. These consist of making the learning content and activities relevant and pedagogically grounded and using cognitive challenges and embedding assessment tools.

Profile and Ownership

Making the gameplay data accessible through a player profile, and allowing players to examine their progress and next steps.

Relevance and Relatedness

Linking the game content with the context of the player, such as their knowledge and/or experiences. The DPs of this class can facilitate the players understanding of how the game activities connect to their own context, by relating to real-world context, familiar activities, and/or past experiences.

Resources and Economy

This class details the inclusion of resources in a game such as virtual currency, points, or achievements, which can engage players to play longer. The DPs can support cognitive curiosity, competition, recognition, rules, and control motivators.

Social Play

Supporting social interaction in the game among the players, which helps facilitate socially engaging game experiences. DPs include using competitive and/or collaborative game activities and enabling communication and interaction through a chat or online forums.

Storytelling and fantasy

Creating a narrative that is either based on a real-world scenario or fantasy can make a game more engaging. This promotes immersion, emotions, and real-world relevance motivators.

3.3.2 Guidelines and Game Elements for Collaborative Games

Designing collaborative serious games is challenging, because of the need to consider the requirements of single-player games, the difficulties with implementing multiplayer games, and the learning aspects of serious games [36]. It is also argued that collaboration in serious games is an unexplored field, and there is a demand for more research and exploration in collaborative play in games. Still, there have been made efforts to collect relevant and effective guidelines and game elements for collaborative games which can be useful in this study.

In [34], Jonassen discovered 11 generalized game design guidelines for co-located co-operative games.

1. Allow taking on specialized and interdependent roles
2. Encourage communication and teamwork
3. Allow players to self-express
4. Elicit pro-social player interaction
5. Design for a range of skill levels
6. Incentivize cooperative behavior
7. Downplay inter-group competition
8. Provide different game modes or rule settings
9. Design for the meta-game
10. Make it easy to rotate in and out of gameplay

11. Foster an enjoyable experience for the audience

In [15], they have performed a systematic review of collaborative games for learning to facilitate the design of such games. This yielded a list of 20 game mechanics divided into 6 categories that support collaborative learning. The categories are *Space*, *Objects, attributes and states*, *Actions*, *Rules and goals*, *Skill*, and *Chance*.

Space

The space category encompasses the game world, where the players collaborate and interact. The players can either be together in the same game world where they can see each other's avatars, or possibly be isolated from each other. The first makes the players aware of each other's presence and facilitates seeking help, while the other can promote communication throughout the gameplay. Within this category, an in-game helping system can also be added to help players who are stuck by e.g. giving hints.

Objects, attributes, and states

This category describes in-game objects that can be seen or controlled by players. These have one or more attributes with information about the object and its current state. Mechanics for collaboration included are tradable resources, information division, and indirect action.

Actions

Actions concern the operations available to the players, and how they can interact with the game world and each other. Collaborative mechanics include a text-based chat system, non-verbal communication systems, and competition between groups.

Rules and Goals

The essential mechanics of a game, where goals define the playing process and the rules detail these goals, what actions are prohibited, and how such actions are punished in the game. This category contains several collaborative mechanics, player team, switching leadership, group briefing, common goal, partial goal, group score, joint rewards, and group victory.

Skill

Skills relate to the abilities of the game characters, which are essential to reach the goals of the game. Collaboration in a game can be enhanced by introducing different roles and abilities and letting the players have different assigned roles. This promotes individual accountability and inter-dependability.

Chance

The final category describes the unpredictability of a game and the element of surprise. Two collaborative mechanics have been found for this category, which are the chosen challenger and the surprise task.

3.3.3 Game Elements for Girls

According to previous research, boys have traditionally shown more interest in video games than girls [37]. There has been an increase in female gamers, but there still exists a significant gap, which can be due to their dislike of games featuring extreme violence, cruelty, and suffering [38]. When designing a serious game for both women and men, it is therefore important to consider what game elements promote engagement and appeal to women, and which ones to avoid. The master’s thesis by Saxegaard [39] describes a collection of game elements that appeal to girls, which can be helpful in this study as the aim is to design a game that appeals to IT students regardless of gender. These game elements can be seen in Table 3.1.

Learning Elements	Engaging Game Elements
Provide information	Rich narrative
Quiz	Reward
Consequential play	Meaningful dialog
Repetition	Engaging characters
Emotions	Consequential play
Points	Appropriate level of challenge
Real scenarios	Cooperative
Sophisticated graphics and sound design	Vicarious adventure

Table 3.1: A mapping of learning elements and engaging game elements for girls by Saxegaard, 2019

3.4 Discussion

The aim of this chapter has been to examine findings in the literature that can aid the design of the collaborative serious game in this study. It is worth noting that the studies presented in this chapter do not comprise the expansive list of studies done in the explored areas, and that there may be other relevant research that has been left out.

Previous research in teaching systems thinking to IT students revealed that games can be a valuable way to provide students with a hands-on experience [8],[29]. An identified barrier to introducing systems thinking to the computer science curriculum is that the concepts can be abstract and hard to grasp, in addition to being difficult to apply in a meaningful way within a course. Designing a serious game where these concepts are applied in a more relatable and hands-on way may therefore help facilitate learning systems thinking. A DP class that can support this is storytelling and fantasy, which promote the emotions motivator. This can also be supported by game elements connected to relatedness and relevance and real-world context.

Furthermore, the literature revealed several frameworks which can help students learn about sustainability and IT, and understand the complex ways an IT system may impact

the wider system it is embedded within. These can possibly be utilized to further the learning in the game.

There is also support for promoting discussion, reflection, talking about values, and learning about different perspectives when teaching sustainability to IT students [1] [22]. This provides further justification for the use of collaboration as a main component in the SG, as this has been shown to encourage social interaction and shared knowledge construction [40]. By utilizing the game elements that aid the design of collaborative games, these learning elements can be further supported by the SG.

When it comes to challenging the students' perceptions, a major component is to avoid teaching sustainability as a problem that will eventually be solved in the future, resulting in a "happy ending" to the issues [22]. Instead, it is seen as necessary to dare to change the narrative towards the very real possibility that the world as we know it will change, and that there is no easy solution that can prevent it. Being faced with such bleak outlooks of the future can create a very emotional response within a person and feelings of dread, but may also be key to motivating real change in their perception of the problem at hand. In an SG, this can be utilized to help challenge the perception of sustainability and IT among the students. A DP class that can support this is storytelling and fantasy, which promotes the emotions, immersion, and real-world relatedness motivators. Creating a game experience that triggers emotion can also make the experience more memorable [32]. Furthermore, the study by Hilty and Huber [25] provide insight into what clusters of content ICT students may be more motivated by, which furthers their engagement with sustainable development topics. The inclusion of content related to these clusters may therefore also help strengthen the engagement and learning outcomes in the game.

In Section 3.2, a collection of educational games on sustainability and IT was looked at, which revealed examples of games that teach sustainability to students in IT. These reveal that games have had a positive impact on the students learning outcomes and engagement in sustainability topics. The findings of this chapter have also uncovered multiple game elements to consider to support learning systems thinking and sustainability, and challenging existing perceptions. Section 3.3 examines the literature on game elements that support collaboration, engagement, and learning, and design guidelines that can be used as inspiration for the game being designed in this study. Collecting a meaningful set of game elements based on such studies can help ensure that the game is cultivating motivation, engagement, and learning. On the other hand, mashing together all of the recommended game elements found will not necessarily result in successfully engaging students and supporting their learning outcomes. Picking out the game elements that make the most sense in terms of learning goals and the target group is therefore key to getting the intended effects of the SG.

By comparing the findings in this chapter, a set of learning elements and engaging game elements with corresponding guidelines is proposed, which can support and inspire the game design process in this study. These can be found in Table 3.2.

Learning elements	Engaging Game Elements	Design Principles
Teamwork	Collaboration Social interaction	Incentivize cooperative behavior Downplay inter-group competition Encourage communication and teamwork
Real-world context Relevance and relatedness	Storytelling Emotions	Exploration Relate gameplay to real-world contexts Relate to familiar activities Create a meaningful story the player can relate to Create thought-provoking scenarios
Communicating ideas and discussion	Different roles and abilities	Allow taking on specialized and inter-dependent roles
Decision-making Consequential play	Control Feedback Rules and goals	Use consistent controls Freedom of choice and control in gameplay Provide instruction and/or tutorials Provide immediate, positive, and useful feedback Common goal Group victory Create progressive goals that build on each other
Competence	Challenge Curiosity Resources	Provide enough time to solve challenges Raise curiosity by interesting/ and or unpredictable challenges Allow challenges to be repeated Provide relevant and pedagogically grounded learning content and activities Provide cognitive challenges Enable collection of virtual goods Information division

Table 3.2: A mapping between learning elements, engaging game elements, and design principles

Chapter 4

Proposed Game Concepts

Based on the learning goals detailed in Table 2.3, as well as the findings in chapter 3, three concepts were found and developed, which is elaborated upon in Section 4.1. The three concepts were then compared and evaluated before one concept was selected for further development and evaluation in Section 4.2.

4.1 Game Concepts

Three different game concepts were developed through an exploratory process, where inspiration was drawn from the learning goals in Table 2.3, and game elements with their connected DPs established in Chapter 3. Existing collaborative games also inspired the process and the specific games that each concept can be compared to are detailed in each concept description. The concepts incorporate these elements in different ways and thus have both strengths and weaknesses when it comes to supporting the learning goals and engagement. There were however some game elements that persisted throughout all of the game concepts, which are detailed in Section 4.1.1.

4.1.1 Common Game Elements

A set of common game elements have emerged in the process of developing the game concepts, which will be presented in this section.

Collaborative

As established in Chapter 2, the game created in this thesis should be a collaborative game. Collaboration can support reflection and discussion, as well as sociability, knowledge construction, and positive game experiences [14].

Digital Games

All of the concepts are digital games as opposed to board games or physical games. A recommendation in [13] was to explore 3d games in the area of SGs for sustainability, as this can create more realistic experiences. With the assumption that IT students are more experienced with computers, and oftentimes use more powerful computers for their

studies than other students, it opens up an opportunity to try out SGs with more complex graphics in a university context.

Real-world Context

The context of all of the concepts in some way relates to the real world, to make the content more relatable and connected to the experiences of the students. This can encourage more reflection on the experiences in the game, and help close any distance they may feel from the problem at hand. This relates to the DP class with the same name found in [32].

Interdependence

An important design principle of collaborative games is to promote inter-dependability and individual accountability, by giving them different essential roles and abilities [34], [15]. This can support the collaboration between the players, as they become reliant on each other to reach the goals of the game.

Narrative

The narrative about sustainability and IT in all the game concepts is not about finding a perfect solution that ultimately results in a "happy ending", in line with the recommendations in [22]. Instead, sustainability will be communicated as something to work towards, and finding ways to enhance the positive outcomes and reduce the negative impacts of an IT project.

4.1.2 Game Concept 1

The first game concept is a co-located adventure mystery game where two players choose between two roles. The context of the game is a tech company that works with many different types of IT solutions. One player is situated in the past while the other player is playing from the future. Both players will be put in the same office environment with different rooms representing the IT projects of the company, which each relates to a sustainability dimension. In each room, there will be tasks for the players, where they will have to come to mutual decisions. Each decision made will have an impact on both the past and the future, which can be observed by the players. The players are not supposed to see each other's screens and will therefore have to communicate and cooperate to solve tasks and reach the goals of the game.

At the beginning of the game, the future is based on the worst possible outcome of the decisions to be made, and it is the job of the players to piece together how to get a better outcome. They will be able to explore the office environment by talking to the non-playable characters (NPCs), inspecting notes, looking for items with clues, solving puzzles, etc. to understand the impacts of different decisions in the specific room. The games are not synchronized online, and the players are not connected in-game which makes development a lot more simple. Instead, the game is synced by making the players choose the same room and input the same decisions, which then lets them proceed on the

same path. The game concept has been inspired by games such as *The past within* and *Keep talking and nobody explodes* which both also feature gameplay where the players have different pieces of information and points of view, and therefore have to communicate to solve puzzles and proceed in the game.

4.1.3 Game Concept 2

The second game concept features an adventure game where the players will be going on a journey together to learn about the impacts of IT and sustainability. The story will revolve around different IT projects that have had critical effects across the sustainability dimensions. There will be a character that narrates the story of these projects and continues the storyline of the overall game as the players proceed. The game will be separated into different levels for each of the IT projects, and in each level, the players learn about new topics related to sustainability and IT.

There will also be different minigames that must be completed before proceeding to the next level. The minigames stay on theme, where the players solve/fight something together related to the topic of the level. The players will be able to choose between two different playable characters, that have their distinguished abilities and looks, and they will have to combine these abilities to complete the minigames. In each minigame, there will also be different resources to be obtained such as health, points, and pieces of knowledge. The points can be used to buy powerups in an in-game store. While the players play through the minigames, the narrator will show up in between games to continue the story. Before continuing to the next level there is a boss where the players must use the knowledge they have gained in the minigames and through the story to fight it. If they choose the wrong answers they lose health and eventually have to restart. The players switch between who answers to further encourage communication and participation. Inspired by games like *Super Mario Bros*, *It takes two*, *Snipper clips*, and *Portal 2*, which are different adventure games that features a rich storyline and/or interdependent roles with different abilities.

4.1.4 Game Concept 3

The final game concept is a business management simulation game in the context of a software development company. The players must work together to create a sustainable software company and the goal is to get through as many days as possible. The players choose between different roles with different abilities (e.g. designer, tester, backend developer, frontend developer, tech lead). The game proceeds with rounds that correspond to days, where the players will have to reach the minimal goals of the project to be able to proceed to the next day. The players earn a shared amount of coins based on the performance of the day, which can be used to implement new updates in the company after each round that have an impact on different aspects of the sustainability of the company. The players have to manage different tasks to finish software projects, and each project is mainly evaluated on its sustainability and different impacts. When the software company has too many trade-offs in the software that is being created, and can't keep up with the sustainability requirements, the game ends. Throughout the game, different events can

happen where the players must make decisions or where the environment they're playing in is impacted, which can either set them back or improve their results. Inspired by other simulation and management games such as *Plate up*, *Sim City*, *Simul-es*, *Software Inc.*

4.2 Selecting the Game Concept

The game concepts were compared to decide which concept to go forward with. The comparison is based on the connection to the learning goals, the engaging game elements found in Chapter 3, and how feasible it would be to implement. Although all three concepts have been created based on the learning goals, game elements, and design principles established in Chapter 2 and 3, they do this in different ways, and therefore have varying strengths and weaknesses.

When it comes to the connection to learning goals, all three concepts in some way incorporate and support these. However, they do differ in how strongly they may contribute to the learning. In concept 1, the players would be put in a real-world context where they are faced with the effects of their decisions, which can contribute strongly to their sense of responsibility and understanding of the impacts of IT systems. It also presents a compelling narrative by showing how badly IT can affect the future and asking the players to change the world for the better. Concept 2 could also be able to present a compelling narrative through storytelling, but might not have as big of an impact given the lack of control the players will have over the story and outcomes. This concept is also more fact-based than the other concepts. In concept 3, players would face the consequences of their choices in a real-world context, but the storytelling aspect is weaker and might not trigger the emotional aspect in the same way. It also might be difficult to present the long-term impacts of the decisions they make and the complexity of sustainability, thus being weaker in introducing the players to systems thinking.

In terms of engaging elements, all of the concepts combine several of the game elements featured in Table 3.2. Concept 1 is strong in storytelling, consequential play, and challenge through puzzles, but weak in resources. Concept 2 is strong in goals, challenge, resources, and storytelling, but weak in consequential play. Concept 3 is strong in goals, challenge, and resources, but weaker in storytelling.

Another important aspect to evaluate is whether the concepts are manageable to implement, seeing that there is both limited time and resources to do so in this study. Game concept 1 could be simpler to implement as it should be possible to play without an internet connection and thus does not require any complex architecture to support the multiplayer aspect. The two other game concepts on the other hand would require handling multiplayer and syncing the data between the players. All three games would require some focus on graphics, although the third concept could be simpler in this regard as it could be implemented as a 2D game with little change in scenes and game objects.

The overview of the comparison of the game concepts can be seen in Table 4.1. Game concept 1 was finally chosen as the concept to go forward with since this was found to be

the most promising concept in terms of the evaluated dimensions. It was also seen as the most intriguing concept that can support the learning goals in Table 2.3 in interesting and engaging ways.

	Learning goals	Game elements	Manageable to implement
Concept 1	Strong for all	Weak in resources	Yes
Concept 2	More fact-based learning	Weak in consequential play	Doubtful
Concept 3	Weak for systems thinking	Weak in storytelling	Slightly difficult

Table 4.1: Comparison of game concepts

Chapter 5

SustainIT: Concept

This chapter will further describe the game concept SustainIT, which has been chosen among the proposed game concepts described in Chapter 4. The storyline, target audience, and learning goals will be further elaborated, as well as the game elements that have been used.

5.1 Concept Description

The game concept chosen in chapter 4 has been given the name SustainIT, and is as previously described a digital 3D collaborative adventure game where the players play in two different times. The players will have to work together to make more sustainable decisions for an IT company based on what they see and learn from their respective perspectives. The game combines game elements from adventure, mystery, and escape room games. The storyboards created for the game can be found in Appendix D.

5.1.1 Storyline

The storyline has been created to be immersive and engaging for the players and is set in a setting of a workplace for IT professionals. The IT company FuturIT has been very successful for a couple of years and the people working there are happy and enthusiastic about their projects. The company is the number one provider of software and IT solutions in the country. Recently, FuturIT has been taken over by the charismatic CEO Thomas Tech, who wants to increase the profits and productivity of the company even more, through any means necessary. When several years have gone by, the office is now abandoned, and the once vibrant and green city is now in ruin, with thick fog and dust surrounding the run-down buildings. The decisions and actions made by FuturIT over time have resulted in a dystopic future, as a consequence of their unsustainable practices and solutions. This is where the players come in. They have been recruited to influence the company in a more sustainable direction, to hopefully change the future for the better. The players play from different times, where one is situated in the past where FuturIT is thriving, and the other is situated in the dystopic future. Together they can communicate about what they experience from their perspectives, to investigate and learn about the impacts of each IT project. These findings can then be used to make more sustainable choices for the company.

5.1.2 Gameplay

The game is meant to be played in pairs, where one player is playing in the past while the other is playing in the future. In the game, the players explore different team spaces within the offices of the company FuturIT, which each relates to a dimension of sustainability. The players will have different perspectives and information available to them, and must therefore communicate what they see and experience on each side to piece together what has gone wrong in each team. They can then make sure the teams make more sustainable choices in their projects to change future outcomes. Some clues can be found in the past, while others lie in the future, and different puzzles must be solved to obtain all of the clues. These puzzles will also require collaboration between the players to decipher them. The players will be able to explore the office and search for clues and information that can inform their choices, by giving them more context and showing the potential consequences of a particular decision. After the decisions have been made they will see the effects in their respective time. The player in the past will see *immediate* effects, while the player in the future will see *enabling* and *systemic* effects. The dimensions of sustainability and the three orders of effect on which the learning content of the game will be based are further described in Table 2.1 and 2.2.

5.2 Target Audience

The target audience of the game is students studying IT at university. As further elaborated upon in Section 2.3, this group was chosen based on the findings that sustainability as a topic has been receiving little attention in the computing curriculum in higher education. The importance of considering sustainability in the IT sector makes it crucial to find helpful and effective ways of teaching IT students about sustainability and IT. There is also a need for addressing the students' perceptions toward this topic, and give them an understanding of how their actions as IT practitioners can have consequences for sustainability in both the near and far future. The purpose of the game is thus to facilitate and promote learning about the connection between sustainability and IT among IT students.

5.3 Learning Goals

The learning goals established for the game can be found in Table 2.3. The goal of the game is to show how IT can have various impacts on sustainability, in an effort to give an understanding of how sustainability and IT are connected. SustainIT will support the learning goals by introducing the students to systems thinking, by making the students discuss and reflect upon the various ways decisions in an IT project can affect sustainability in different dimensions, both positively and negatively. It will also show that the effects happen both in the short and long term, by letting the player in the past see the immediate effects of their choices, while the player in the future sees the enabling and systemic effects. The story of Airbnb and its various impacts has been used as an illustrative example in [10], to show how an IT solution can end up with severe unintended effects on sustainability. This example will inspire the team project featured in

the game concept as well, to have a relatable case where the effects are already known. The hints the player can find in the game will thus point toward the chain of effects that are displayed in Figure 3.1.

The main goal is to develop an understanding within the students that all decisions taken while creating a piece of technology can have unintended consequences. They should learn that it is important to consider the dimensions of sustainability and analyze the potential impacts of the technology they are creating, and from that understand how to make more sustainable choices in the design of IT systems. The game should also give the students a better understanding of their responsibility to implement sustainability in their IT practice and challenge their perceptions towards the issue of IT and sustainability.

5.4 Game Elements

The game elements used in the concept will be further detailed in this section, and an overview can be found in Table 5.2. These have been inspired by the findings in Chapter 3, which resulted in a collection of learning and game elements with related design guidelines which can be seen in Table 3.2. Although the game elements have been divided into learning elements and engagement elements, these categorizations are not strict as they all can promote both outcomes.

5.4.1 Learning Elements

Decision-making and consequential play - In SustainIT, the players are faced with different cases with a set of choices, where they must analyze and discuss the information available to them to make a decision. These decisions then affect the game world, by implementing the effects induced by the input choices. Some of the found recommendations for teaching about sustainability and IT in Section 3.1 was that students should learn to ask questions about the systems they are making and what problems they will solve, and where this skill can be utilized [1]. Furthermore, students should be critical and reflective, and avoid mindless compliance with directions given at the top level. By allowing the players to alter the outcomes by making informed decisions, they can gain an understanding of how questioning the direction and design choices in an IT project can be of value, and reflect upon the ways these choices impact sustainability. This learning element also furthers all of the primary learning goals detailed in Section 2.3, by making the players think about the complex nature of sustainability, giving insight into the impacts of IT and the different effects, and making them face the consequences of their decisions for an IT system.

Teamwork and communication - The players are separated into two different times, and should not be able to see the perspective of their partner. This can create a bigger incentive for cooperation and discussion, as [15] notes that spatial isolation can encourage communication. This element also addresses the recommendation of making students engage in debates and seeing problems from different perspectives [1]. Furthermore, a recommendation for sustainability serious games was to strengthen the intensity of social

interaction [13]. Creating an environment that pushes the players to collaborate and communicate can enhance their teamwork skills, and create a space for mutual sharing of knowledge and experiences, which can further enhance the learning outcomes.

Real-life context - The game is set in a realistic office space, and the storyline features an IT company with projects rooted in real-life cases, such as Airbnb, which can display relevant examples of how sustainability and IT are connected. This can help link the game content to the knowledge and experiences of the player, in line with the relevance and relatedness DP class [32]. Thus, this game element can further promote the learning goals of the game, by referencing documented impacts of IT on sustainability that are both immediate and long-term.

5.4.2 Engaging and Motivational Game Elements

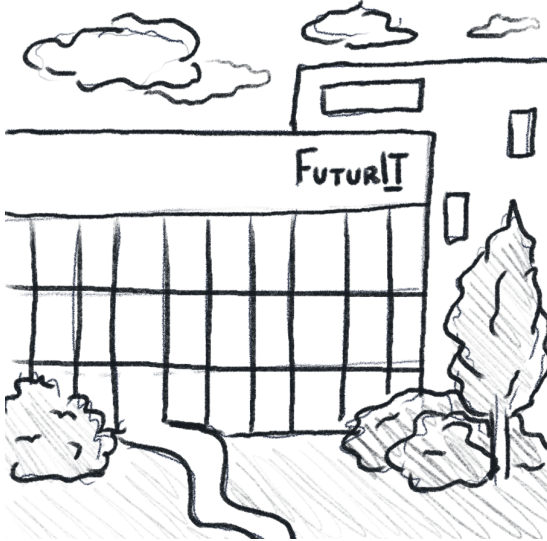
Storytelling - The game has a storyline that features both real-world scenarios, and dystopic future scenarios. The story also promotes the common goal of bettering the sustainability of the company, to save the world from the dystopic future scenario. Storytelling can promote engagement and motivation through immersion, real-world relations, and emotions [32]. The storyline was also created to display how IT impacts sustainability and aims to trigger emotions within the player by not sugar-coating the potential consequences of not addressing sustainability, but instead exaggerating the game environment in the future to make a clear point. In [22], they argue that taking on the perspective of *doomsday sustainability* instead of *vanilla sustainability* can inspire more fundamental action. The storyline can therefore also support the learning goal to challenge students' perceptions of IT and sustainability.

Control - The game will allow the players to make choices that result in different effects in the past and the future. The players will also be able to explore the office space and the teams in any order they please and control the player character's movement. The game therefore promotes the control motivator which relates to the autonomy of the player and their ability to influence the game world and its events [32].

Collaboration - Collaboration is also an engaging and motivating element in the game, that was already established as a feature in Chapter 2. In SustainIT, the players must collaborate in order to proceed in the game and if one player quits the other will not be able to go on in the game. Inter-dependability and taking on different roles have been noted as important in promoting collaboration in games [34], [15]. This can cultivate a socially engaging experience, and further promote the learning element of teamwork and communication. Cooperation is also found to promote engagement in girls [37].

Puzzles and challenge - The game concept will feature escape-room-like puzzles that must be solved in order to find all relevant information and hints that can help inform the decision-making process. Challenge can be a powerful motivator provided the player perceives it as fair, and cognitive challenges can also support the learning process [32]. The puzzles will also require the players to collaborate to solve them, as the hints and solutions to each puzzle will be spread across the past and the future. Including puzzles

in the game can also promote exploration and curiosity in the players, and further push collaboration between the players.



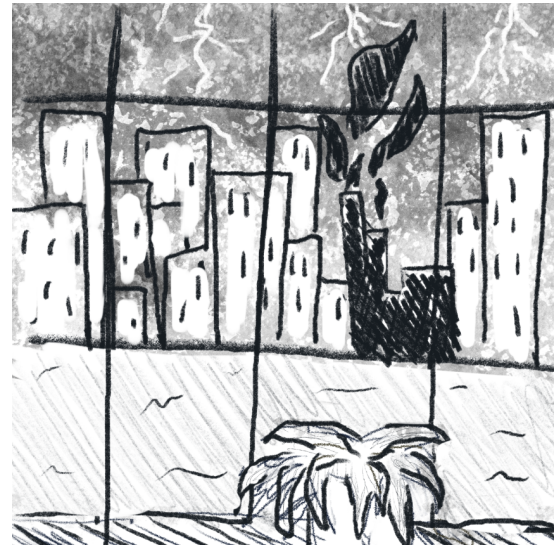
(a) The FuturIT office from the outside in the past



(b) The boss, Thomas Tech



(c) The worried protagonist



(d) The view of the outside world in the future

Figure 5.1: Sketches illustrating the story-line

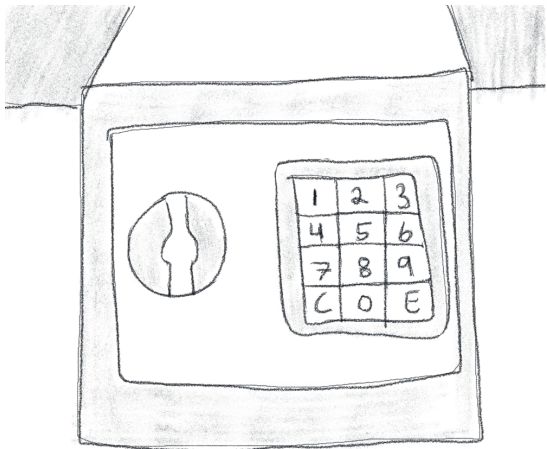


(a) The office space with different elements to inspect and interact with

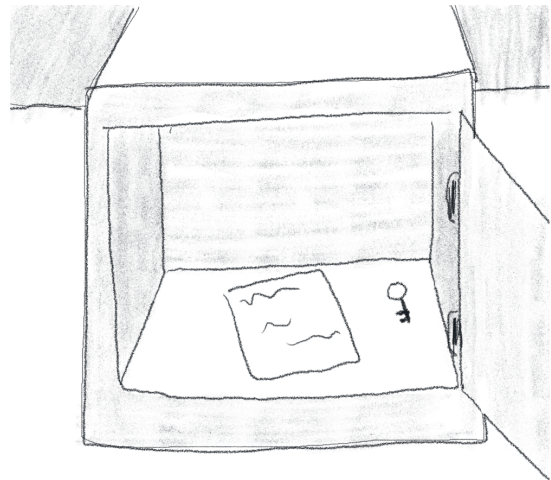


We are working on a new house showing platform, and we would like your opinion on something.

(b) A conversation with the tech lead of a team



(c) The safe before the correct code has been input



(d) The safe opened and showing its contents

Figure 5.2: Sketches illustrating the gameplay

ID	Learning objective	Game activities
1	Learn systems thinking	Displaying the complexity of sustainability by showing how different IT projects can have multiple various impacts outside of the system itself, based on the available information. Players must discuss how these impacts came to be based on the hints and information they find and try to find the more sustainable decisions with the least trade-offs
2	Gain insight into how sustainability and IT are connected and understanding that IT systems not only have immediate impacts on sustainability but there are also long-term effects	Seeing and discussing the different ways an IT project impacts sustainability related to the sustainability dimension of each team room with each other, based on conversations with NPCs and information pieces obtained in the game. Displaying that IT can both have positive and negative impacts with the hints and information given in the game. Seeing the effects of their choices, and how they play out differently in the past and the future.
3	Challenging the perception towards IT and sustainability	Engaging with the storyline and game world, and making joint decisions based on the information available. Seeing the future visualizing a worst-case scenario, and the consequences of their decisions in both the past and the future. Giving the players the possibility to change the outcomes in both the past and the future.

Table 5.1: Mapping of learning objectives to game activities

Learning elements	Engagement elements
Decision-making	Storytelling
Consequential play	Control
Teamwork & communication	Collaboration
Real-life context	Puzzles

Table 5.2: An overview of learning elements and engagement elements in the game concept

Chapter 6

Concept Evaluation

In this chapter, the first evaluation of the chosen concept will be presented. Three semi-structured interviews conducted with a game expert, a sustainability expert, and an IT student will be described, which were conducted after the concept was chosen in Chapter 4.1 and further elaborated upon in Chapter 5. The game expert reviewed the first version of the storyboard and concept described in Chapter 5, while the sustainability expert and IT student reviewed the next iteration that was created based on feedback from the game expert. Both the first and second storyboard reviewed in these evaluations can be found in Appendix D.

6.1 Purpose

The main purpose of the interviews was to evaluate the concept at an early stage and get feedback on the feasibility and quality of the concept. The evaluation could help confirm the potential of the concept, both as a viable game experience, as well as a tool that can support learning about sustainability in IT. Receiving feedback from relevant experts and a person from the target group could also bring insights into the strengths of the concept, as well as the elements that need further work. The feedback will then be used to further improve the game both in terms of game design as well as content and learning.

6.2 Participants

Two experts from the supervisor's network were recruited for the interviews, where one was an expert in game design and the other was a sustainability expert. Additionally, one IT student was recruited from the author's network. The experts were chosen for the evaluation based on their backgrounds in game design and sustainability respectively, which could bring valuable insight in terms of game elements and learning elements, and how they may support the learning goals described in Table 2.3. They could also share their opinions of what they saw as strengths and weaknesses of the concept. The game design expert was specifically recruited to assess the quality of the storyline, the game mechanics, and the suitability of the game for the target group. The sustainability expert was recruited to evaluate the quality of the content and learning elements, and to

give their opinion about the suitability of using such a game to support learning about sustainability and IT. Finally, the IT student was recruited to give feedback on their perception of the game concept and provide insights into their previous experiences with sustainability and IT. All of this feedback could then be utilized to develop the concept further and avoid any unforeseen pitfalls.

6.3 Process

In total, three semi-structured interviews were performed with the participants. A semi-structured interview guide offers coherent instructions that can yield reliable and comparable qualitative data, as well as the opportunity to follow up on any relevant topics that emerge during the interview [41]. This allows for the collection of interesting insights that may not have come to light with a more structured interview. Each participant was interviewed individually and the evaluations were held digitally through Microsoft Teams. All of the evaluations consisted of a presentation of the storyboard and a description of the concept, in addition to the semi-structured interview. Furthermore, the evaluation with the sustainability expert and IT student included an additional semi-structured interview before showing off the concept, to learn more about their understanding of IT and sustainability and gain relevant insights from their perspectives. Both storyboards used in this evaluation can be found in Appendix D, and the interview guides can be found in Appendix C. The evaluation was facilitated by the author alone.

The original plan was to voice-record the evaluations to ensure the correct rendering of the results and allow the author to focus on following up on the answers during the interview without the distraction of note-taking. However, due to unexpected issues related to the voice recording feature in Microsoft Teams, it was decided to use the built-in transcription feature they provide instead. This was found to be efficient and accurate for the most part, although there were some sentences throughout that were not transcribed accurately. In the student interview, the transcription was therefore supplemented with voice recordings through *Nettskjema* to fill in the gaps of the transcription. Before the interviews took place, all participants received an information letter detailing the study and its purpose and informing them of their rights to withdraw their consent at any time. The information letters distributed to the participants can be found in Appendix B.

It is important to emphasize that the game expert reviewed the first version of the storyboard and overall concept description, while the sustainability expert and the IT student reviewed the second version. The implemented changes between the evaluation with the game expert and the evaluations with the sustainability expert and IT student are detailed in Table 6.1. The changes can also be seen in the second version of the storyboard in Appendix D.

6.4 Results

This section will present the results from the evaluations done with the game design expert, sustainability expert, and IT student. The section will first detail the evaluation

with the game design expert in Section 6.4.1 who reviewed the first version of the concept and storyboard. Then, the results of the evaluation with the sustainability expert and IT student will be presented together in Section 6.4.2, as they both reviewed the changed version of the concept and storyboard and had a similar structure to their evaluation process.

The interview guides were slightly different for each participant to better target the specific expertise and insights they could provide. The interview guide for the game expert was focused on the game design parts of the concept, while the interview guide for the sustainability expert was more focused on the learning aspects of the game. In the interview guide for the student, the pre-defined questions were directed toward the opinion and perception of the game concept. Additionally, the interview guides for the sustainability expert and IT student were both divided into two parts, where the first dealt with their experiences related to education in sustainability and IT, and the next focused on the evaluation of the game concept.

The qualitative data gained from the semi-structured interviews in these evaluations were analyzed through thematic analysis [42]. All of the records from the evaluations were fully examined in order to collect relevant and interesting points and statements shared by the participants. These were then further divided and mapped into themes relevant to answer the research questions and further inform the development of the concept.

6.4.1 Interview with Game Design Expert

This section presents the results of the evaluation with the game expert.

Feedback on Concept and Engagement

The first impression was that he liked the concept, and thought it was interesting. He also thought that there were several engaging elements included in it.

”Collaborativeness, sociability, and storyline. So you have a lot of these things. Mystery is very engaging if it is a good mystery”

He pointed out the storyline and narrative as especially compelling features of the concept and thought focusing even more on those aspects could be beneficial in further development. He further noted that storytelling is one of the most engaging components of a game. The expert also found that sociability through collaboration is a strong component to promote engagement among the players. Furthermore, the escape-room-esque puzzles in the game were viewed as strengths, and he thought that the back-and-forth communication to solve the puzzles would strengthen the collaboration between the players. He advised strengthening the collaboration by putting emphasis on distributing essential elements in the past and the future which had to be shared between the players. When it came to aspects he was concerned about, he pointed towards the “time travel”- aspect of the game, and expressed that it would be important to be careful when implementing this in the game, as it can be challenging to do convincingly. *”It would need to be tight and cohesive”*.

To further promote engagement, the expert suggested incorporating competitiveness into the game, by for instance including a leaderboard or similar that could motivate the players to want to get further in the game or to beat the scores of other teams. He also suggested that the game could end if the players made too many unsustainable choices, which would mean that the players would have to restart the game and try different alternatives. This could then increase the replayability of the game.

Learning Aspects

The game expert thought that the collaborative aspect and the decision-making mechanic where the players can see the results of their choices was a really interesting part of the learning aspect of the game. He reflected that making the students aware of problems with IT and sustainability, and making them discuss and reflect, could possibly contribute towards them going into the working life and doing something about it, although he thought it would be hard to test within the scope of the project. Furthermore, he thought it was important to clarify the learning elements of the game more and how they connect to the learning goals, as he perceived them as a bit unclear. When it came to the end of the game, he noted that listing up the scores was probably not going to have a big impact on the players, as it could be easy to dismiss at the end of the game. He instead proposed to put the focus on the storyline, and that the end goal for the players could be that they find out what happened to the company, and to unravel the mystery of why the world ended up the way it did in the future.

6.4.2 Interview with Sustainability Expert and IT student

This section presents the results of the evaluations with the sustainability expert and the IT student. In the previous evaluation, the game expert expressed a need for clarification on the learning aspects of the concept. He also provided game design-related insights that were considered valuable to add to the new iteration of the concept. It was therefore important to review these elements in the concept description and storyboard before the interview with the sustainability expert and IT student. This resulted in a second version of the storyboard and concept, with the implemented changes described in Table 6.1, which has been reviewed in the evaluations detailed in this section.

Sustainability and IT

When the sustainability expert was asked about the state of sustainability in higher education from her perspective, specifically in IT and technical studies, she said that there is a lot of literature out there promoting sustainability in IT and engineering education, but that there is a lack when it comes to implementing it in the study programs themselves. She however noted that this boiled down to there being many challenges connected with it.

"It really depends on the teacher, on the professors and how relevant they think it is, and also how suitable it is for the course that their teaching. We talked to some teachers who thought it was really important, but they teach, I

don't know, C++ or something, So they don't really know how this should be added to their course, because it doesn't make sense in what they teach"

She also thought time and available resources are major hindrances, and that it can be challenging to make the content feel relevant to the students.

"I remember one example where, in a course, the task was to develop online teaching content on the SDGs, the Sustainable Development Goals. And in itself, the task was completed well, but then the feedback was that the students didn't know why this was relevant. And it just seemed completely disconnected from what they were trying to learn from what they're studying."

She further expressed that there is also the challenge of what level of knowledge the teachers should expect from the students as well, and to ensure that they feel the content is interesting and new.

For the question about what is important for students in IT to learn about sustainability, the sustainability expert answered that they should learn about how everything is interconnected and that every choice you make both depends on and influences other choices or other systems. The students should reflect on the design choices they make in their projects, and learn about the impacts these choices can have even years later, and that decisions can have unintended consequences.

The IT student was asked whether he had previously had any courses on sustainability and IT, and his answer further indicates that there is little content on sustainability and IT in the curriculum:

"There has been one course during my studies where sustainability was incorporated, however, it had nothing to do with the IT aspects of the course, but rather the domain of an app we were making. Otherwise, there have not been any other courses where it has been a topic as far as I remember".

However, when asked if he would like to learn more about sustainability and IT, he enthusiastically agreed:

Yes, I feel like it's something I really know very little of, and it's not something I've learned about. So I feel it would have been exciting to learn more. Sustainability is really important, and everyone talks about the environment and climate, although not so much in the context of IT. We are building the green revolution and all that, but how specifically has IT been or is involved in that? I don't know much about that"

About using games as a learning tool in university, he said it would be nice to use games as part of the lectures and coursework because it makes can make it a lot more fun. *"I think games in education provide a very nice break [from regular course activities] while still providing learning outcomes."* He further noted that there has not been much use of games in his courses, other than Kahoot, which he thought was a shame.

General Feedback on Concept

Both interviewees found the concept exciting and convincing and both commented that they would like to play the game themselves. The student stated that he could imagine the concept as a fully-fledged game. The sustainability expert also expressed that she thought the concept seemed well-connected. When it came to the strengths of the concept, the sustainability expert thought that it was nice that it could be self-administered so that the students can choose when and where they want to play it, and they can take their time with it. She thought that it could be very beneficial for learning to have an exploratory setting where the students can engage with the content. She also thought that the game seemed suitable for the target group.

Overall, the participants were very enthusiastic about the game and struggled to point out any parts they liked less. However, they did offer some constructive feedback. When asked about elements they were more unsure about, the student only pointed out that although the storyline works well to communicate a message to the players, it would be necessary to make sure that the storyline didn't go too far, and become overly moral and preaching in its overall message. The sustainability expert noted along the same lines that the storyline could be viewed as a bit extreme, but she still thought it was fine in a game context. However, she suggested making the timeline a bit longer, as it could be more realistic that the future of the game would be more than ten years away.

Engaging Elements

When the student was asked what elements he liked the most, he mentioned several things.

"I liked the Escape-Room elements. I really like Escape-Rooms so I am maybe biased by that, but I think it's a very cool aspect. I also really liked the fact that you have to talk to your partner, that you don't see each other's screens, and that you have to communicate and stuff like that. And that what you do has consequences for the future, and that different choices you make give different results".

The sustainability expert noted that adding competitiveness could further promote engagement, and suggested letting the players compete to find the best combination of advice with the best possible outcome that would be available in the given scenario. She thought that this might encourage the players to get further in the game. On the other hand, when the student was asked about what he thought about adding competition to the game, he noted that it could further engagement, but that it might be difficult to implement if the idea is to not have "correct answers" in the game. He ultimately thought that it would be a good enough reward to see that the future became better based on the actions in the game.

Learning Aspects

The sustainability expert pointed out that she liked the fact that the learning goals of the game matched those she had provided as the crucial things to learn earlier in the

interview. She thought it was good that the players had to discuss and communicate their perspectives and reach a mutual decision about the advice. She also thought that it could be a helpful way to learn about system thinking, especially with the advice being created and then receiving feedback for the impact of the advice. She however also noted that it would be essential to make sure that the content is relevant for the students, by for instance including advice for design decisions in a project. She, therefore, emphasized that the learning outcomes would depend on the way the advice and outcomes were implemented, and recommended looking at existing cases and using those as inspiration to make sure the decisions and resulting impacts are well connected.

The sustainability expert was especially intrigued by the advice-giving mechanic and provided some suggestions for how it could be further developed. She thought it could be nice to let the students go back and input new advice after seeing the impact of their previous choices so that they could see how different combinations could have different results. This could be done by letting the players go back to scratch, or by making the results build upon each other to create a chain of impacts. She also suggested that there could be one combination of advice that was considered the most sustainable, to let the players have a goal to reach for. She was on the other hand worried that the sentence creation mechanic could be limiting for the students if they wanted to create advice outside of what the mechanic allows them. Even so, she also thought that it could be difficult to implement an alternative with even more freedom. She further wondered if there should be some sort of introduction to the theory behind the content, such as describing the concept of sustainability, as not all students may have the same background knowledge.

"I don't know if, for players that are maybe very new to the whole concept of sustainability, if there should be a theoretical introduction. But at the same time, I feel overloading a game with theory is not fun. So it's maybe something that should happen prior to playing the game. If it's used in a teaching context then it could be up to the educator to provide the necessary background."

On the other hand, she further noted that the students not necessarily needed to know the theory behind the dimensions and the orders of effect to learn something from the game, but that it could be nice as a bonus material that they could go further into if they were interested.

The IT student also thought the learning aspects of the game were interesting.

"I know that short-term rental for example affects the housing market, but I may not have thought too much about the fact that the IT systems behind enable it. (...) Yes, it's something I'm writing about now, like automation and AI and all that kind of stuff, and what influences they have. So I think it's very relevant, especially for the developers to have in the back of their minds"

For the question of whether the game could be useful to learn more about sustainability and IT, he agreed.

"Yes, absolutely so. If I had the game, I would easily try it, as the concept was cool. It's definitely something I would have liked to learn, and there are

probably others who could also think so because nearly the biggest focus of today is sustainability and things like that. So I definitely think there is interest for it”

6.4.3 Discussion

The evaluation of the game concept of SustainIT yielded several interesting and helpful insights, which both help confirm the viability of the concept, as well as providing valuable feedback to be considered in the proceeding iterations of the game design. Overall, the game concept was received with enthusiasm by all participants, and the opinion of the second version of the concept was that it was well-connected. They all thought the game concept had potential as an interesting and engaging game and as a tool for learning about sustainability and systems thinking in IT. However, it is important to note that the feedback gained from this evaluation is not necessarily reflective of the opinion of the target audience at large. The next iteration of the prototype should therefore be evaluated further, to provide more insights into how well the game works in terms of engagement and learning.

The interviews confirmed that the concept contained several elements that can promote engagement. The game elements pointed out as especially engaging were collaboration, mystery, escape-room puzzles, decision-making, and storytelling. The game expert thought that it would be beneficial to play up these elements even more, to further the engagement. Both of the experts also commented that it could be nice to introduce competitiveness by having teams compete against each other to make the best decisions or get the furthest in the game, while the student was more unsure if it was needed. Competition is therefore an element that could be interesting to implement in the game. However, using competitive contexts in gamification has been found to sometimes harm educational outcomes and motivation [33], and have also been found to lessen engagement with girls [37]. It was therefore decided that this would need further investigation, which lay outside of the scope of this study.

The participants viewed the game as relevant for learning about sustainability and IT, especially in the second version of the concept. In terms of the potential for learning systems thinking, the sustainability expert was positive, but did also emphasize that it would be important to create a good connection between the advice and the resulting outcomes. She provided some interesting suggestions for the advice mechanic, such as allowing the players to go back and choose different advice, or to let them build upon their decisions after the feedback has been provided. Both experts and the student also had similar ideas when it came to having a combination of decisions/advice that was deemed the best. It will therefore be important to further develop the advice and feedback mechanic and to clarify the goal of the game. The sustainability expert also made some interesting observations about the inclusion of relevant background information in the game, which should be considered in future iterations.

Changes

In this chapter, the game concept for SustainIT has undergone two iterations of change, one based on the results of the evaluation with the game design expert, and the second based on the feedback from the sustainability expert and IT student. The changes in both the first and second iterations of the concept can help strengthen the game concept both in terms of learning and engagement and make the concept more comprehensive. The resulting changes of both iterations have been further detailed with their corresponding reasoning in Table 6.1 and 6.2.

Changes to first version of the concept			
ID	Feature	Description	Reason
1	Storytelling	Including in the storyboard that the player in the past will be given the task of inspecting the different teams of the company, to make sure they are on the path of increasing both profits and productivity.	This gives more context to the actions of the player in the game, and why they can change the direction of the projects in the first place, and further improves the storyline in line with the advice given by the game expert.
2	Team rooms	The rooms were changed from representing one dimension only to having all the aspects present.	To allow the players to not only analyze the sustainability in one dimension at a time but to also see the interdependence between them, which can better show the complexity of the impacts and therefore support the learning goal for learning systems thinking
3	Decision making	Changing the mechanic from giving the players a small set of possible options to letting them create sentences that would form the advice for the team instead. The sentence creator will contain a collection of words and connecting sentences, that the players can use to create a range of different advice.	To promote more reflection and discussion between the players on their alternatives, and make it more difficult to guess the answer without having searched the rooms thoroughly. Giving a larger sense of freedom to the players which support the control element in the game
4	Ending	Removing the score view, and instead focusing on showing the effects of the decisions	To motivate the players further with the storyline and seeing the results of their actions, in line with the advice given by the game expert

Table 6.1: Changes made to the concept after the game expert evaluation

Changes to the second version of the concept			
ID	Feature	Description	Reason
1	Decision mechanic	Having a combination of the three advice sentences that gives the least negative outcomes in the future, while still not being a combination without tradeoffs	To have a clearer goal to strive for in each room to further the engagement, and to support showing that no result provides a "Happy ending"
2	Learning content	Adding parts of the SusAF framework described in Chapter 3 as elements to find in the game	To give the players more explicit information about the sustainability dimensions and orders of effect in the game, which they may use to contextualize the different hints they find in the game and help the decision-making process.
3	Storytelling	Making the actual timeline of when the future is more obscure	To remove the element of doubt and questioning whether it is possible for such a bleak future in x amount of years. It was seen more as a distraction than an important detail in the concept.
4	Ending	Allowing the players to go back after seeing the results of their advice, and look for more clues before trying new combinations	To improve replayability, and enable the players to try out different combinations so that they can see how the outcomes differ.

Table 6.2: Changes made to the concept after the sustainability expert and student evaluation

Chapter 7

SustainIT: Prototype Implementation

In this chapter, the implementation of the working prototype of SustainIT will be described. This version has applied the changes detailed in Table 6.2, and taken the concept from a storyboard and description to a playable prototype. The repository containing the source code and Unity files can be found at <http://tiny.cc/sustainit>.

7.1 Game Engine

Unity is the most popular game engine to use for game development in the world, and 50% of mobile games and 60% of Augmented Reality and Virtual Reality games have been created with it [43]. Unity is free to use with many helpful features, and it aids game development by handling common game tasks such as physics, rendering, and input [44]. Unity is also cross-platform and can be used to create both 2D and 3D games, and it has a large community behind it that provides tutorials, assets, and help on online forums. Additionally, Unity provides access to an asset store where one can find both free and paid resources such as models, animations, audio files, etc. The C# programming language is used for scripting.

Multiple other game engines provide many of the same features as Unity, such as Unreal Engine and Godot. However, Unity was chosen among other popular game engines mainly because the author already was familiar with the tool through previous endeavors. Furthermore, the author had more experience with the C# language than languages such as C++. It was therefore seen as beneficial to avoid spending too much time on learning a new tool, leaving more time for implementing the game prototype.

7.2 Prototype

The prototype of SustainIT is a 3D game application that has been developed in the game engine Unity, using the C# programming language. The prototype has been built for Windows, Apple Silicone Mac, and Intel-based Mac, and can be downloaded through <https://benedihi.itch.io/sustainit>.

7.2.1 New Features

The implemented prototype includes the changes listed in Table 6.2. Additional new mechanics and elements have also been considered in the development from storyboard to playable prototype, to further support playability, learning, and engagement. These are comprised of an in-game tutorial, an inventory, and a hidden items mechanic. One of the engaging game elements found in 3 is feedback, which can be supported by providing instructions and/or a tutorial in the game. This can provide players with a more equal ground at the beginning of the game, and help the players learn the mechanics of the game. To let the players have the items they find available at all times, an inventory has been introduced, which supports the resources game element. Hidden items that could be found by inspecting objects in the game were also added, to expand the controls available to the players. The mechanic can promote the challenge, curiosity, and exploration motivators found in [32], and can be used to further support the puzzle game element. Furthermore, the viewable items in the game were further developed from the initial ideas featured in the storyboards in Appendix D, to provide various hints in the game related to the case of a short-term rental platform and its particular possible impacts on sustainability.

7.2.2 Functional Requirements

A set of requirements for the prototype was created based on the established concept and game elements in Chapter 5, the changes added in Chapter 6, and finally the new features that have been found beneficial for the playable prototype in Section 7.2.1. Due to the limited time and experience with game development, in addition to being only one developer, some of the intended functionalities of the game had to be omitted, to have a working prototype that could be tested and evaluated within the boundaries of this study. It is important to emphasize that the goal of this research has not been to implement a fully functional game, but instead to evaluate and test the game concept and its game elements, to see how these are perceived and understood by the target group. The objective has therefore been to include features of the concept that were both feasible and important to test in a functional game context. The prototype therefore only provides a minimal viable product of the game concept. Section 7.2.3 will elaborate further on the features that did not make it into the final prototype. The chosen requirements for the prototype can be found in Table 7.1.

7.2.3 Non-Implemented Features

Because of the limited time and resources in the study, some of the intended features detailed in Chapter 5 and in the changes after the concept evaluations in Chapter 6 could not be implemented in the prototype. The most important feature that was omitted was to change the game environments based on the advice sentences the players create, to visualize the different impacts of their decisions. This feature was seen as too big to be able to implement in the amount of time available, due to the multitude of ways the effects could have manifested based on the input advice. Although a solution could have been to limit the number of sentences the players could make, this was seen as a bigger limitation in showing off the concept, as it could make the collection of hints easily disregarding. Communicating the effects to the players after they finish the advice in

the evaluation of the prototype was therefore seen as the better solution. The intro to the game that shows off more of the storyline was also not implemented, as this would be time-consuming. The storyboard featuring the intended intro could instead be shown in the evaluation to give an introduction to the storyline in the game. Other than this, the rest of the intended elements of the game were implemented, albeit in a limited way.

7.2.4 Gameplay

The prototype starts with a game menu where the players can choose between playing in the past and the future. Each player is positioned in different versions of the FuturIT office, and the environments provide different ambiances. Both players begin in the hallway and have a prompt panel in the upper right corner, giving them prompts regarding the in-game tutorial. Via this prompt panel, the players are guided through the controls of the game, before they are asked to go to the boss's office. Here, the player in the past receives the quest to improve the different teams, while the player in the future is alone. Both players are asked to look for items, which are letters detailing the problem and goals of the game, the tablet that "syncs" the players with each other, and hidden items that provide them with one piece each of an information paper explaining the sustainability dimensions and three orders of effects. When they have these, they proceed to the offices of the short-term rental team.

The short-term rental team office contains more items to be found and inspected in both the future and the past. In the past, the player can speak to the NPCs that are spread around the room, and learn more about their thoughts about the project they are working on. The future version of the office is again empty but contains other types of clues as to what went wrong. Additionally, one puzzle has been implemented, which is the safe puzzle. One of the NPCs tells the person in the past that they have forgotten the code to their safe, where a key to a file cabinet resides. This is critical because the file cabinet contains important documents that their boss has requested. He continues to say that he *"really needs to find a better way to remember the code."* There are no more clues for the code in the past, but a wall containing Polaroid pictures on the same desk that the safe is by can be found in the future. These provide the key to finding the code, as they contain pictures with different motives that can be counted. If they do this, they will find the code "1201".

Finally, when the players have found all the relevant info, they can begin to input their advice sentences for the team. The player in the past talks to the tech lead, while the player in the future uses their tablet. The advice panel contains a set of words and a set of sentence connectors that can be combined in multiple ways to form advice sentences for the team. The players input three sentences, and when they are finished they have reached the end of the prototype.

7.2.5 Scenes

The game was structured into different scenes, representing the different rooms of the office the players could go into. Every scene except for the start menu had two versions,

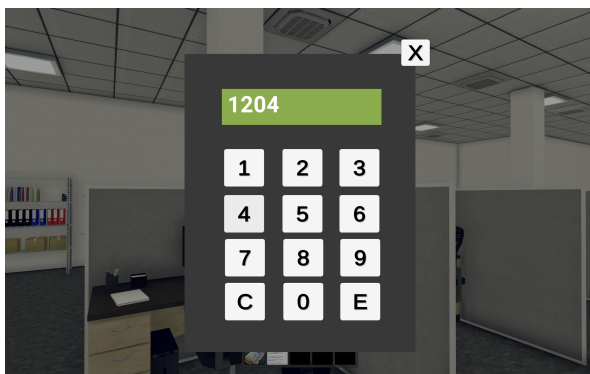


(a) The conversation with the boss in the past



(b) The player in the future finding items to pick up in the boss office

Figure 7.1: Screenshots of the gameplay



(a) The safe before the correct code has been input



(b) The polaroids referencing the code

Figure 7.2: Screenshots from the puzzle

one for the player in the past, and one for the player in the future. The total amount of scenes was 9, including the initial hallway, the boss’s office, the second hallway, and the final short-term rental office.

7.2.6 Mechanics

Unity offered a package containing a third-person character controller asset, which was used as a base for the playable characters. The asset came with common control mechanics of a playable character, such as walking, running, and jumping. The rest of the implemented mechanics were created from scratch, with the help of tutorials made by the Unity community. The mechanics and their corresponding controls can be seen in Table 7.2.

7.2.7 Game Models

All models used in the game have been either found in the Unity Asset Store, poly.pizza, or created by the author herself. Additionally, some of the animations in the game have

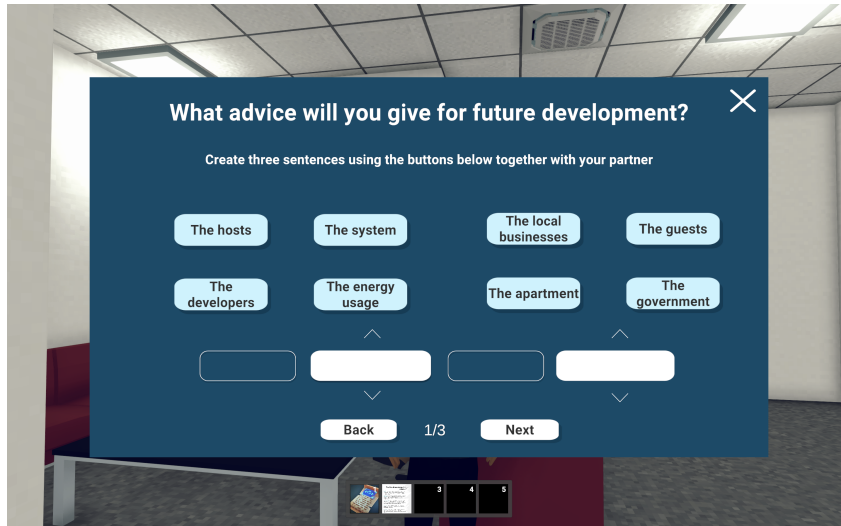


Figure 7.3: The advice sentence panel

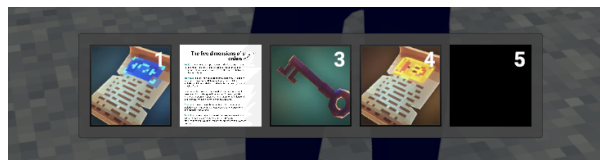


Figure 7.4: The inventory which was visible at all times throughout the game

been found through Mixamo.com. The models from the Unity Asset Store are licensed under Extension Asset, the ones from Poly.Pizza were either CC-0 or CC-By, and the animations from Mixamo were completely free to use. The models licensed under CC-By have been credited in the prototype through a credit window accessible in the game menu.

Characters

Two character models were used in the game, one for the player in the past, and one for the player in the future. The past character model was chosen based on its general look as an office worker, while the future character model was chosen to further give an impression of the environment in the future as hazardous or difficult to breathe in due to the full body suit. These choices could then further illustrate the contrast between the past and the future. The models can be seen in Figure 7.5.

Items

A collection of items that the players could pick up and bring with them in an inventory was created in the prototype. The items that could be found in the boss's office consisted of the letters that gave an introduction to the story and goals of the game, the informative papers on the *sustainability dimensions* and *orders of effect* which is further explained in Table 2.1 and 2.2, and the tablet enabling the player in the future to input advice sentences and see the SusAD. Furthermore, in the short-term rental office, there was a key that could be obtained by solving the puzzle, a document reporting future plans for



(a) The playable character in the past



(b) The playable character in the future

Figure 7.5: The playable characters in the game

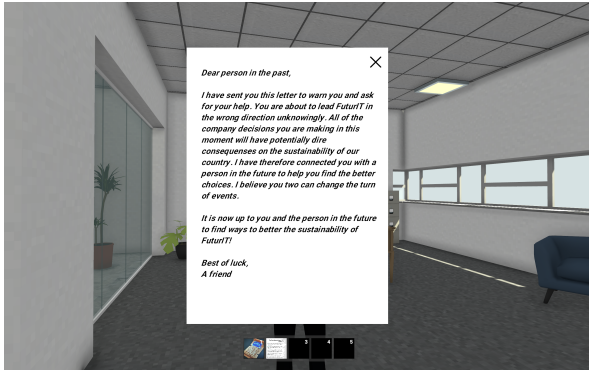
the short-term rental platform which could be found using the key, and a newspaper in the future referring to the impacts of the platform.

ID	Requirement	Reason
1	Enabling the players to play in either the past or the future	A vital part of the game concept, as it sets up the collaborative element and the premise for the concept
2	A puzzle to solve	Allows testing how well puzzles can work in the game, and how the players can work together to solve them from both perspectives
3	An in-game tutorial	Helps the players get started and informs them of the controls they can use
4	Dialogues with NPCs in the past	An important element to provide the player in the past with hints and clues to the puzzle and the impacts of the IT project
5	The advice panel	An important mechanic to test, as this is where the players can connect the different hints and clues they have found to inform their decisions on what they think will reduce the negative impacts of the IT project
6	Distinguishing the ambiance and visuals of the past and the future	Strengthens the storytelling element of the game by emphasizing the difference between past and future, and communicates that something has gone wrong to create the future environment
8	Enabling players to pick up and hold on to items in an inventory	Allows the players to bring the initial items with them from the boss's office, and to look at them from wherever they are in the game environment. Also helps the puzzle by visualizing that the player in the past has obtained the key
9	Enabling players to inspect for hidden items	Strengthens exploration of the game environment and adds to the puzzle component of the game
10	Enabling players to look at items in inventory	Important to allow the players to read the content of the items they find such as the letters and newspaper
11	Enabling players to look at hints that cannot be picked up	Helps build up the puzzle element and adds different ways to engage with the elements of the office space

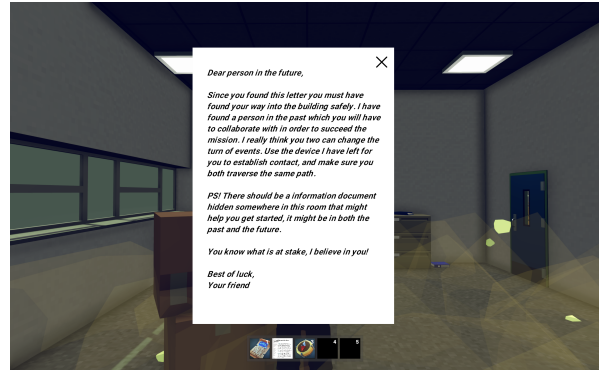
Table 7.1: Requirements for the implemented prototype

ID	Mechanic	Control
1	Walking	WASD keys or the arrow keys
2	Running	Holding down shift while walking
3	Jumping	Spacebar
4	Interacting with doors, items, NPCs	E-key
5	Inspecting elements for hidden items	I-key
6	Interacting with UI-elements	Mouse pointer
7	Looking at items in the player inventory	Corresponding number-keys to the ones visualized in the inventory

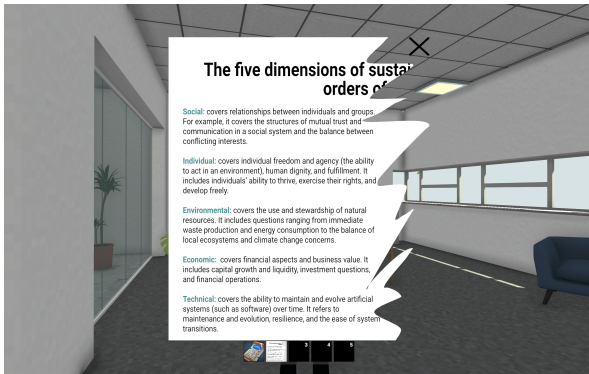
Table 7.2: Mechanics and their corresponding controls



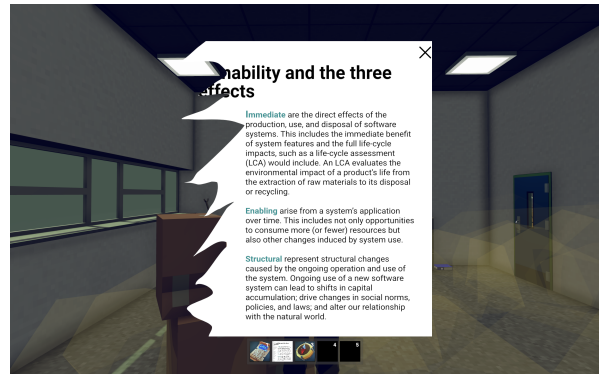
(a) Letter found in the past



(b) Letter found in the Future



(c) The paper cutout detailing the sustainability dimensions found in the past



(d) The paper cutout detailing the orders of effect found in the future



(e) The newspaper found in the future



(f) The tablet that could be found in the future

Figure 7.6: Some of the items that can be found in the game

Chapter 8

Final Evaluation: IT and Sustainability Expert

This chapter will describe an evaluation of the implemented prototype of SustainIT described in Chapter 7, which was conducted through an interview with an expert in sustainability and IT. Before the expert evaluation, a pilot evaluation was held with two volunteers outside of the target group, to reveal any usability issues. The expert evaluation was centered around the game elements and the game's potential as a learning tool in sustainability and IT, to further help answer **RQ1.1** and **RQ1.2**.

8.1 Pilot Test

Before the final evaluations of the implemented prototype, a pilot test was conducted to catch any usability issues or other errors that could potentially affect the results. Assessing the game before the main evaluation reduces the chances of unintended problems with the game, and allows for making necessary changes to the implementation in time. The test was conducted with two voluntary participants outside of the target group who both were familiar with playing games in their free time. Although they did not have prior knowledge about IT, they could still be able to uncover any issues with the game mechanics and overall experience of the prototype. The game was tested on an Apple silicone Mac and a Windows computer. The test was facilitated by the author.

8.1.1 Observations

The pilot test was conducted with two participants using different computers in the same location. They were introduced to the game and then left to play through it together while the author observed them and took notes. Overall the participants had a positive attitude toward the game, especially regarding the graphics and storyline. They also thought it was engaging to play together. There were however some issues that emerged throughout the play-through.

The first observation was that the UI elements in the game were a lot smaller on their computer screens than intended. They could still read and see the elements but commented that some people might struggle with the small text. Another issue that happened

was that one of the participants lost their mouse pointer after they activated the pause menu while looking at the sticky notes. The participant had to restart the game because of this issue in order to continue playing.

Both of the participants noted that the game felt a bit empty. They felt that even though there was a big space to explore, especially in the team office, there was not a lot to find and do within that space. They also both expressed difficulty finding interactable items. The safe was easy to miss as it was positioned on the floor mostly outside of the player's field of view. The sticky notes were also too well hidden and took a long time to find for the participant playing in the future. They, therefore, suggested moving these items to a more visible place. They also struggled with finding the key code since there was no limit to how many digits they could input. The game did not communicate that they were supposed to look for a 4-digit code, which made the puzzle way more difficult. Furthermore, they wanted some feedback after they were finished inputting the advice. The game did not provide any feedback on whether they were done after finishing the advice sentences which they found confusing.

8.1.2 Discussion

Since the participants of the pilot test were not representative of the target group, the results of the evaluation may not give any indication of how well the learning and engagement aspects of the game work for the intended target group. Nevertheless, the evaluation uncovered a set of usability issues that could have interfered with the main evaluations of the prototype and possibly influenced the results. Some of the issues found in the pilot test were too complicated and/or labor-intensive to address in the short amount of time between the pilot test and the final evaluations. Some were also viewed as ultimately not vital to change for these evaluations, such as the emptiness of the game space.

8.1.3 Changes

After the pilot test, the found issues were considered and prioritized based on their severity and feasibility to be addressed before the final evaluations. The implemented changes ranged from minor issues that could lessen the experience such as typos and scaling of the UI elements, to more severe issues that could inhibit the players such as duplication of items and losing the mouse pointer. The implemented changes after the pilot test were all deemed manageable to address with the amount of time left. The final implemented changes to the prototype can be found in Table 8.1

8.2 Purpose

The purpose of the evaluation with the expert in sustainability and IT is to assess the implemented prototype of SustainIT. The goal is to determine whether the game has potential as a learning tool and the suitability of implementing the game in a course. The aim is also to receive feedback on the use of game elements to support engagement and learning, and whether they work well or not. The evaluation can therefore help answer **RQ1.1** and **RQ1.2**. The teacher could also be able to provide feedback on the

ID	Feature	Description	Implications for gameplay
1	Keycode	The keycode was limited to four digits	Intermediate
2	Placement of safe and sticky notes	Making the safe and sticky notes more visible	Intermediate
3	Scaling of the game	Make the game scale better on different screens.	Minor
4	Items	Kept spawning if the player went back into a room, which was addressed by removing the ability to go back. A check to see if the players have all their items before leaving a room was thus also implemented.	Major
5.	Advice panel	Give feedback that the advice has been finished when three sentences have been created.	Intermediate
6.	Pause menu	Fixed the issue where the mouse pointer was gone if the player goes into the pause menu while looking at an item UI.	Major
7.	Text	Fix typos and grammar.	Minor

Table 8.1: Changes made to the prototype after the pilot evaluation

prototype which could be considered in future iterations of the game. Since SustainIT at this point is only a working prototype rather than a fully-fledged game, usability has not been a focus in this evaluation.

8.3 Participants

The recruited participant for this evaluation was an expert in sustainability and IT who has experience with teaching these topics to IT students. The participant was recruited from the supervisor’s network. The background knowledge and experience with both sustainability and IT, as well as teaching the topic, gives the expert a great foundation for giving critical feedback on the implementation of the game and its learning objectives. Their teaching experience may also help the assessment of whether the game is relevant for teaching sustainability and IT to IT students.

8.4 Process

The evaluation with the expert was held digitally via Microsoft Teams and started with an introduction to SustainIT and the study before giving a presentation of the game prototype. Because the game is a collaborative game with two players, it would be difficult to let the expert play through the prototype by themselves. Two videos were therefore filmed beforehand to facilitate the game demonstration. Since usability was not an element to be considered in this evaluation, this was seen as satisfactory for the purpose of the evaluation. The presentation started by showing the first part of the storyboard to represent the intro of the game. Version 2 of the storyboard used in this evaluation can be seen in Appendix D. Then, both videos were played side by side to demonstrate both the gameplay in the past and the gameplay in the future simultaneously. Explanations of what was happening were given while the videos were playing, in addition to answering any questions that emerged. The crucial elements of the game concept that had not been implemented in the prototype were also elaborated upon, such as the fact that there should be visible effects on the game environment showing the outcomes after the players have finished their advice sentences. These non-implemented elements are further described in Section 7.2.3. It is worth noting that presenting both sides of the gameplay at the same time could be overwhelming and confusing to a spectator, which could have resulted in an unclear perception of the different game elements and how they work. However, the facilitator made sure to let the participant know that she could ask questions throughout and also stopped the videos several times during the presentation to explain certain elements more thoroughly.

After the game presentation, a semi-structured interview was conducted with the expert, to learn about their perception of the implemented prototype, and what they thought about the learning and engagement elements that had been implemented. The participant was also asked to give their opinion on whether the game could support the learning goals described in Table 2.3, and if the game could work in a teaching context. The questions were therefore divided into two parts where one related to the game concept itself and the general perceptions of it, while the other was targeted towards the learning objects and suitability for facilitating teaching and learning. The evaluation as a whole was transcribed using the built-in functionality in Microsoft Teams. An information letter detailing the study, the purpose of the evaluation, and the rights of a participant was sent prior to the evaluation. The interview guide with the pre-defined questions used in this evaluation can be found in Appendix C, and the information letter can be found in Appendix B.

8.5 Results

This section will present the results of the evaluation of the implemented prototype of SustainIT with an expert in sustainability and IT. The findings have been analyzed through thematic analysis as described in Section 6.4.

8.5.1 General Perception of the Game and its Potential

The expert conveyed that the concept piqued her interest, as she has previous experience using the SusAF in workshops with students.

"First of all, I think it's very exciting since I actually work a bit in this area myself. So I get a lot of thoughts about what, what can this be used for and what could this become? Yeah, I'll probably keep thinking about it and what could be done further with this."

She thought it was exciting and fun to see the models used in a game context, as it presents it in a different way than she is used to seeing and using the framework in workshops.

"(...) What is exciting in your case here, is how much information do you need beforehand to fully appreciate or be able to use the model? I think that's an interesting aspect, and I think it's great fun to see this in a gamified version because then it's even more fun [than in a workshop context], right?"

She also thought the game could potentially open up opportunities for working with the framework without having to plan and conduct a traditional workshop. On the other hand, she believed it would be necessary to put the game in a bigger facilitated context, where the students are prepared for the game content beforehand, or possibly add a reflection and discussion session afterward to understand more about what the different students learned. When asked whether she thought the game could be integrated into a course, she was positive about the idea but still maintained that there would have to be some context around the game to fully exploit the learning potential.

"The first answer is yes, I think you could use it, but like I said, I think I wouldn't do it in a way that, "Today it would be nice for me as a course manager to relax a bit. (...) No, it would have to be part of an arrangement. It must be thought through."

She also reflected on the purpose of using the game in a course and thought that although the purpose could be to learn about SusAF, she recognized that the main objective of the game is to point out the complexity of sustainability and make the students think through how the decisions IT practitioners make in their solutions have large consequences for the future. In that sense, she admitted that the framework was more subordinate in this case. This was followed up with a question if she thought it could be a nice "taster" before going into more detail in a lecture or workshop.

"I think so. Speaking of the process around it, it is true that in a way this is the start of something where one can discuss experiences from the game, or in other words you use it as a springboard into going deeper into for example the framework and the mindset. Because then they have something to hang on to when you start discussing the model itself."

Furthermore, she thought that it would be nice to introduce the game as early as possible in the curriculum because then you have more time to push the students to consider these things in their projects. Then the knowledge could be built upon in later courses.

8.5.2 Engagement Aspects

The expert thought that playing in the past and the future, and the dystopian future scenario in the storyline was particularly engaging and that it adds more value and motivation to the game. In her opinion, many would find such a story exciting, and it can make players interested in understanding what happened to create such a future. She also believed that most people would buy the premise that the players can communicate across time, as this is common in movies with time travel aspects as well. When asked if she thought the story was too bleak in terms of the future scenario, she emphasized that although there should be a balance in realism, she felt it was important to wake people up and not be afraid to present the scary and ugly sides of sustainability. She liked that the game took the topic seriously and that the purpose was not to find an ideal solution to all the problems where everything was fine, but instead show that it's about balancing the good and the bad and finding tolerable solutions.

She also liked the escape room part of the game with solving puzzles and thought it could be very engaging. On the other hand, she was unsure if the puzzle would be too challenging and pointed out that it is difficult to know before testing if a puzzle is too complicated. She believed that the puzzle implemented in the prototype could be difficult to solve for the players. Finally, collaboration was also an aspect she pointed out as engaging, as it can be more fun to play in pairs.

8.5.3 Learning Aspects

Overall, she found the content of the game relevant for learning about sustainability and IT and pointed out that the example with Airbnb is typical for a reason, as it is important to have a recognizable case. When it came to systems thinking, she thought that the game was well on its way, but would like to see even more emphasis on visualizing the complexity. This could for example be done by displaying the effects in the SusAD in the game. She also noted that it would depend on the connections the students were able to make with the sentences and the framework.

"Seeing all of the alternatives for solutions and aspects of these in the advice sentence mechanic, I think that can help give insight into the complexity and systems thinking, but the context around the game and what the students already know will be as important as what happens in the game."

When it came to collaboration, she thought it would be a great support for learning by eliciting discussion among the students and aiding them in the problem-solving parts of the game. It could also be a motivator for learning, especially in the context of one person being in the past and the other being in the future.

"I myself am very concerned about that, the whole issue with sustainability and students' learning about sustainability, the future need for competence related to sustainability, is about dealing with future scenarios with great complexity, with a lot of uncertainty. Perhaps there is a need for cooperation, as is done here in a way, to discuss [these issues]."

She also pointed out the advice sentence mechanic as an important element to support learning, as it can direct and structure the discussions and reflections that emerge in the game. She further reflected on the limitations put on the creation of advice and thought it could be both a strength and a weakness. Even though it could feel restrictive on one hand, it could also make it easier for the students to have something concrete to choose from rather than having to think of the possible solutions from scratch as they usually do in the SusAF workshops.

She was also positive about the usage of the SusAF since she has had positive experiences with it herself, although she was curious to see if the way it is presented in the game would add to it and/or take something away from it. She wondered if the students would be able to make the connection to the rest of the game elements without a proper introduction, but also thought it was an interesting experiment to conduct.

"I think it's great fun that it is being used in new ways and the usage of a game at all. So that is very good. And then I think that especially with some data from testing with users here, it could provide very useful input for further research and testing associated with this model."

When asked if she thought the game could promote a change in IT students' perception of the importance of sustainability and IT, she noted that any efforts to make students think about these topics are beneficial.

"Everything that you bring with you that enables you to connect these things, like 'Oh yes, I understand this a bit, because I have come across this before'. If you know what it's about, have a little more foundation, and have thought a little more about these things before you go out into the work life, I think it's important."

She however also asserted that we should not underestimate the students, as many of the IT graduates already know a lot about sustainability and have strong attitudes toward the issue. On the other hand, she still thought that it would be beneficial to make them more aware and that games could be a familiar gateway into these topics for many students. She also pointed out that making the connection between the smug boss with money on his mind and this future scenario, and showing that decisions have consequences for the future and how this connects to IT solutions can come across well. She overall thought the game had potential in this regard, but emphasized that it can be different for every person and that ultimately research would be needed to reveal how effective it is. *"I hope many of them will make the connection, and the more we can push them to do that, to make that connection, the better."*

8.5.4 Proposed Changes

She noted that it could be interesting to create other examples than the Airbnb example, where the future outcomes are not as clear and easy to interpret based on what you already know about events that have happened. She also suggested that students could be included in the creation of the cases used in the game, which could be a motivating task. Another point she brought up was that she suspected there would be individual

differences in how the students would approach the game and that some students might be more willing to look for clues and puzzle together the pieces, while other students might be more impatient and less willing to take their time with it. She, therefore, suggested that it might be beneficial to provide different ways to play to support the various types of players. In terms of the inclusion of SusAF, she explained that in the workshop the students usually have the diagram printed out in large formats, and sit around it while creating sticky notes that can be moved around. She, therefore, suggested that implementing interactivity in the diagram in the game could be valuable to utilize the known strengths of the workshop version.

8.6 Discussion

The evaluation with the expert in sustainability and IT provided interesting insights into the perception of the game elements and learning aspects of the prototype, and its overall relevance and potential for teaching sustainability and IT to students in IT. The interview also yielded helpful insights into how SustainIT can be further improved, as well as how it could be used in a learning context.

The general feedback from the expert was that the prototype was thought-provoking and fun, and she was positive toward the idea of using it as a learning tool in teaching sustainability and IT. Her assessments indicate that the game is engaging and that it includes different aspects that can support the learning goals. However, she underlined that she was not sure to what extent the students would learn by the game alone, and overall commented throughout that it would be important to put the game in a bigger learning context, where more information about the contents of the game could be given, and discussion and reflection around the game experience could be facilitated. It could therefore be interesting to test the game in such a context with a teacher facilitating the introduction to the material, and discussions after playing the game.

One of the game elements that were viewed as engaging was the storyline. The expert liked how the contrast between the past and the future was implemented in the aesthetics, and thought that playing with the concept of time could be intriguing to the players. She also thought that it was a good way to let the players see reality in the eye, by facing them with the not-so-nice aspects of future scenarios. She also pointed out that the escape-room-like puzzles and the collaborative aspects were engaging, and that collaboration could support the problem-solving element of the game. Additionally, she was interested to see how the collaborative elements played out when the game was tested, and what types of discussions they could support. These insights can further confirm the choice of game elements in the game concept described in Section 5.4 and their connection to the learning goals.

It was clear from the results of the interview that an aspect of the prototype she found very interesting, was the use of SusAF. As a result of the insights provided by the sustainability expert in the concept evaluation described in Chapter 6, items describing the sustainability dimensions and the order of effects were added to the game. At this point

in the design process, this addition was seen more as bonus material and an extra hint, which could support the players in piecing together the different impacts they learn about in the game. It could also help them create advice sentences based on how they thought these changes to the project would play out. In [4, p. 492], they argue that the SusAF "could be used by students independently and without previous knowledge", although they were still provided a basic introduction on sustainability and the SusAD. The expert on the other hand was unsure if the students would be able to connect these dots on their own and apply the framework in a meaningful way. She had only seen it used in a workshop context and thus thought it was an interesting experiment to explore how little background knowledge is needed to understand the use of SusAF. This will therefore be an aspect that will be further looked upon in the upcoming evaluation with students, to learn more about how the framework best can be embedded into the game.

Chapter 9

Final Evaluation: Group Evaluation with IT Students

This chapter will describe the final group evaluation of the implemented prototype for SustainIT by participants from the target group. The implementation of the prototype tested in this evaluation is further detailed in Chapter 7. The participants were given a survey before the evaluation, tested the prototype, and participated in a group interview. The findings of this evaluation could then further contribute to answering **RQ1.1** and **RQ1.2**.

9.1 Purpose

The purpose of the final group evaluation is to assess the implemented prototype of SustainIT with the target audience of the game. At this point in the process, the concept has been implemented into a working prototype that can be played in pairs, although some of the intended functionality is still missing, as described in Section 7.2.3. The evaluation aims to see how the game is received by the target group and gather insights into which elements support engagement and learning. The participants could offer valuable feedback on the perceived learning and engagement outcomes, as well as pinpoint elements and shortcomings that need further development. The participants could also offer valuable insight into their own experiences with sustainability and IT and their perceptions toward the topic.

9.2 Participants

A group of six students studying IT were recruited through the author's network. The group of students included three male and three female participants that ranged from 3rd, 4th, and 5th-year students, two in each year. The students were recruited to examine how the game is perceived and understood by different people in the target group. The evaluation could also give an indication of how well the engaging elements and learning elements work and the perceived learning outcomes. Observing the students during the test could reveal any challenges with the controls and if there were any aspects of the game that were more difficult to understand. Testing the game with different computers

could also reveal any platform-related issues that could lower the quality of the game experience. All participants were given an information letter detailing the study, the purpose of the evaluation, and their rights as a participant before the evaluation which can be found in Appendix B.

9.3 Process

To have more context for the results gathered in the observation and interview, a questionnaire was distributed to the students before the evaluation. The purpose of the questionnaire was to learn relevant details about the participants' prior experience with sustainability in their studies, their experience with games, and their perceptions of sustainability and IT. The answers to the questionnaire could help bring context to the results of the evaluation, and understand where the participants were coming from in their feedback for the game. The questionnaire consisted of one part asking about their experience with sustainability and IT and games, and another part where they were asked to give a score on a Likert scale featuring five response options from *strongly disagree* to *strongly agree*, to seven statements related to sustainability and IT. The statements used in the questionnaire were inspired by the principles and commitments detailed in the Karlskrona Manifesto [2]. The questionnaire can be found in Appendix E.

The evaluation of the prototype was performed in person in a classroom with the author acting as the facilitator. All of the participants were gathered in the same classroom, and divided into pairs based on which study year they belonged to. The students were asked to bring their own computers, and the game was thus tested on three different platforms: Windows, Apple Silicone Mac, and Intel-based Mac. First, the students were introduced to the game and shown the first part of the second version of the storyboard visualizing the intended intro of the game, which can be found in Appendix D. Afterward, the students were asked to play through the prototype together and to ask for help if they got stuck. The facilitator observed the students while they played, and took notes describing any interesting observations or issues that arose during the test. However, since the facilitator was alone in doing this, it was done to a limited extent. Some valuable observations may therefore have been lost in the process. When the participants finished playing, and had input their advice, it was explained that the game should show the effects of the advice they have created for both players and that the players would have been able to go back to input new advice if they wanted to see a different outcome. This had to be communicated verbally, as these features did not make it into the implemented prototype, as explained in Section 7.2.3.

After the play-through of the prototype, the students were gathered for a semi-structured group interview to learn more about their thoughts and experiences from playing the game and ask for feedback on the learning and engagement aspects. The interview questions were divided into two sections, where the first part related to the general perceptions of the prototype and game experience, to determine whether they found the game elements and mechanics interesting and engaging. The second part focused on the perceived learning outcomes of the game and their thoughts about using the game for learning about

sustainability and IT. The participants sat in a circle facing each other and were asked to raise their hands if they had any thoughts they wanted to offer to the asked questions. The interview was voice recorded to make sure the answers and feedback from the students were represented accurately and to allow the facilitator to focus more on following up on the answers. The interview guide used in the group interview can be found in Appendix C.

9.4 Results

The results of the distributed pre-questionnaire, the observations during the prototype test, and the semi-structured group interview will be detailed in this section. The results of the evaluation have been analyzed in a similar way to the one described in Section 6.4.

9.4.1 Questionnaire

50 % of the students reported that they have been exposed to the topic of sustainability in relation to IT through their university studies. All of the students also had experience with playing games, although the frequency of playing differed, and most of the students had played games in courses at the university. Almost all of the answers to the statements part of the questionnaire leaned towards highly agreeing and agreeing. However, for statement 2, *"Sustainability has been an important factor in my prior IT projects"*, the answers have landed on the other end of the scale. Some of the results of the questionnaire have been visualized in Figure 9.1 and Table 9.1. All of the responses to the pre-questionnaire can be seen in Appendix F.

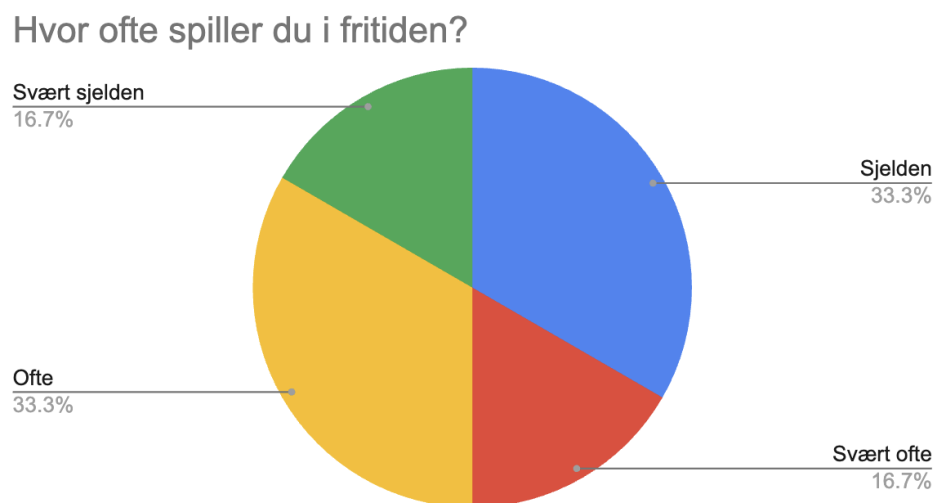


Figure 9.1: The students' frequency of playing games (n=6)

9.4.2 Observations

Notes were taken while the students sat in pairs and played through the prototype. These observations will be presented in this section.

ID	Statement	Mean score
1	Jeg ønsker å lære mer om bærekraft i sammenheng med IT	4.8
2	Bærekraft har vært en viktig faktor i mine tidligere IT-prosjekter	1.7
3	IT kan løse bærekraftsutfordringene vi står ovenfor i dag	3.7
4	IT er en del av bærekraftsproblemet	4.5
5	Bærekraft er komplekst, og det er ikke mulig å finne en enkelt løsning på utfordringene	4.7
6	Bærekraft må tas hensyn til selv om IT-systemets primærfokus ikke er bærekraft	4.7
7	Jeg har et ansvar for langtidseffektene av systemene jeg er med på å bygge	4.7

Table 9.1: Results of the statement part of the pre-questionnaire (n=6)

Gameplay

An observation was that the pairs of players all approached the collaboration part in different ways. One pair started off discussing everything they saw in the game right away, while another pair were more conservative in sharing their observations in the beginning. Furthermore, all of the student pairs struggled with the safe-code puzzle for a long while, and the facilitator had to eventually give hints in order for them to solve the puzzle. Still, most of the pairs had the right idea and were close to solving it themselves but struggled with finding the exact code. There were also issues connected to the "Hidden items"-mechanic, which emerged from the confusion of which key to press. Some of the students were confused with the difference between pressing the E-key (Interacting with doors and items) and the I-key (Inspecting for hidden items), which resulted in them not being able to find the hidden item in the boss's office. The facilitator therefore had to intervene when this was noticed, to inform them of how to use the mechanic. It was also observed that the participants chose to create the advice sentences before they had finished the puzzle, and even before finishing the exploration of the team room.

Technical issues

While most of the computers ran the game fairly well, two of the participants using Intel Macs suffered from performance issues. The game was slower and lagged during the gameplay. The student with the most lag in the game ended up using the facilitator's computer instead, to lessen the impact on the results of the evaluation. Two of the students also ended up having issues where the mouse disappeared when they tabbed out of the game, which resulted in a restart of the game for these students. However, they found a way around the problem when it happened again.

9.4.3 Group Interview

General feedback on the concept

Overall the students expressed that they thought the concept was interesting, fun, and creative. One student stated: *"I think it has a lot of potential, it was a very good idea that can be built on."* Another student said: *"I think it was fun to solve it together. It felt a bit like a game night with a friend"*. The students thought that the sustainability theme was exciting, as they think it is an important topic. *"It is a different way to interact with such a topic than what we normally do."* The students liked the storyline as well and thought the design and atmosphere especially in the future were nice. Some of the students thought that it seemed more exciting to be the player in the future, due to the playable character having a "cool" design and the dystopic atmosphere. Contrarily, another student pointed out that it seemed like the past world was more exciting as they could talk with NPCs and possibly learn more about the story.

On the other hand, they thought some mechanics did not work as well, such as the "hidden items"-mechanic. Some students mistook which button they should press, and some commented that it should somehow be indicated where one should look for such items. A student also commented that they thought the room was too big in comparison to how many things there were to find and do. Furthermore, there was a general perception that the mechanics and goals in the game could be clarified even more, such as the advice sentence mechanic and hints distributed in the game.

Engaging elements

The students liked the escape room aspect and the puzzle and thought that it was a big motivator to play the game. *"Opening locks and codes and understanding the world around you, the environment, and how the past influences the future. I think that is the engaging game elements that help."* The students agreed that the most engaging game element was the collaboration aspect, and they viewed it as a strength of the game.

"When you are two players playing together, you feel more pushed to continue working through the game, and it eases the frustration for both of us [when they were struggling with finding things]". "It is a very necessary element that makes the game fun (...), I don't think the game would be as fun without it."

When they were asked if they thought it was challenging to cooperate, the students relayed that it was difficult to know what to convey to their partner.

"It was difficult to know how much I was supposed to say, like, should I make a list of all the stuff that exists in this room, or is it enough to give a general description?"

The students thought this was especially prominent with the different papers they found in the game.

"(...) when there is suddenly a lot of text, it can be tiring to read it aloud to the other person. And then you have read 100-200 words, and you're like, is there nothing here, or is there a point to it?"

About the storyline, they said they liked it, and a participant playing in the future thought it was fun especially in the future to see that things had *"Really gone to hell"*. When asked if they thought it was okay that the future was dystopic, they all strongly agreed. *"You can 'hammer the point home' in a way. Show that like, things can go horribly wrong if you don't do anything."* A student expressed that it was a necessary component to make the game fun:

"After all, it's a game, so things have to be entertaining too, to make people want to play it. Then you have to exaggerate a little, although it is not necessarily an exaggeration, as you don't know that. But it must be a bit clear. It must be representative."

Another student also reflected that it might make the effects resulting from the input advice more clear when they make the future better.

Learning Elements

Generally, they all thought the papers detailing *the five dimensions of sustainability and three orders of effect* were a bit obscure, and that it was difficult to understand their purpose. They also did not understand the purpose of the SusAD included in the tablet in the future. Another issue was that some of the students found the language complicated, and wanted less text and more clarity. One student however noted:

"We probably didn't try to understand it either. We thought that it will probably come to a point where we would need it, so we can come back to it then. And then it ended with us never actually reading it."

When asked if this applied to the rest as well, another student commented:

"Even though we read it aloud, because we read quite a lot in the beginning, it was like, I didn't take it too much to heart. I was just passing on the information. And then I sit and look at the other person who doesn't process the information either."

When asked if they would like to have an introduction to the framework before playing, one student expressed that they would have rather had both papers available to both players, although another disagreed as they thought it was important to divide them to support the collaboration. Some students brought up that they would rather have it more obviously connected to the puzzles in some way so that they were forced to try and understand what it is about. The students also thought it should be condensed into fewer sentences.

Furthermore, the students had some thoughts about the advice sentence mechanic and expressed that it was difficult to understand how they were supposed to deal with it. Some of the students recounted that they began creating the advice before they looked at the puzzle, but then were unsure if they were supposed to do it after. They ultimately thought this could be made clearer.

Perceived learning

When it came to perceived learning, the students expressed seeing IT and sustainability in new and different ways. Some of the students noted that they had not really thought about how dramatic the effects of IT on sustainability can be before and that they became more aware of the ways it can impact sustainability. Although, one student confessed that he might have learned more if he had read the contents of the items more carefully.

"I became more aware of things, maybe. About short-term rentals and things like that. I hadn't thought much about how it's problematic before. But when you read that newspaper article, you became more aware of it, at least. I did not bother to read through everything that was written on the one half of the paper. So I could probably learn more if I had bothered to do that"

The students also felt they got a new perspective on IT and sustainability:

"I see how IT has a greater sustainability impact on other things than I had thought before. Before I thought that we have to be careful not to use, like, the cloud uses a lot of energy as an example. But the systems you create for Airbnb and such is also a large part of it. It may not necessarily be directly IT-related, but it is in a way, yes, at least to some extent IT-related."

The students also talked about their experiences with sustainability in their courses at university and generally viewed them as lacking in this aspect.

"I feel at the study program, we learn a lot more about implementing environmental measures in the code itself. In the web development course, for example, you kind of get, 'Now we're going to create environmentally friendly code', but it doesn't go further than that. As in, you need to think about the whole picture, not only this line of code. That's something you get more of [in the game], here you get a more wide perspective."

One student also pointed out that there is too much focus on the positive aspects of IT, and too few critical questions asked in the study program:

"[About the NPC standing by the water cooler] It reminds me very much of being at the university and in work life, which is all about "Everything is so new and cool, we have to make a lot of cool stuff" and stuff like that, but it is never talking about the societal problems we have and the moral questions of IT. Although there is a lot you can think of yourself, there is very little focus on it in IT studies (...) So I think it's very important to focus more on it, even though you might know about it already. (...) the most important thing is to get the thought process started, and then you can become a little more aware of it when you see it in real life yourself, perhaps."

When the students were asked if they felt more motivated to consider sustainability in their future projects, they all agreed. This was followed up with a question of in what ways they thought they would do this, which generated the following answers:

"Maybe avoid, or maybe think a little more about projects I'm asked to work on and consider whether I should say yes to them in the first place".

Another student said:

"For me it was like, if you consider going into an entrepreneur role, or to a start-up company, there is a lot you can influence, as an individual. Just speaking up about things, or saying what I think is not wise from a sustainability perspective to someone who has very big ambitions, and a slightly narrow perspective."

On the question of whether something changed in their perception of sustainability and IT, one answered:

"In line with what [participant] said, even if you are asked to create a system, and even though it is not us who decide that the system should be created, one should perhaps be more aware of how one, well what one agrees to create, and to take a little more responsibility."

Another student further reflected upon this:

"I think in general, because in the game you maybe don't have the role as an IT developer, in a way, it's a bit more of an adviser, so you see the problems from 'ok, what goals should we have, and what should we focus on', and IT practitioners might not always have that opportunity to choose. But it is as you say, we can choose which jobs we accept, and if no developer want to work on projects that have unethical consequences, then they wont be created"

Potential for Use in Teaching Context

When asked who they thought the game would fit for, the students thought it should be introduced as early as possible.

"I missed a focus on sustainability a little earlier in the study program here. I think, even now in my master studies, there is very little, even though I seek it out. So getting that perspective early, in the first and second year can be good. And especially since [the game] is not that technical, I think it could be a good fit in a first-year subject. There are also more students who appear in lectures in the first year."

One student on the other hand also noted that it could be good to introduce it later as well, as the students might be more aware of their own situation and have more experience with developing systems and working in IT in general. On the question of what they thought about using the game in university education, they were positive. *"I miss interactive lectures, like when we had Kahoot in the first year. When it's the only thing we've had, almost, it's... Games are fun". "It's a nice break as well, even though you're still learning."*

9.5 Discussion

In this section, the discussion of the results will be presented. The evaluation yielded several valuable insights that can help understand the strengths and weaknesses of the prototype and the perceived enjoyment and learning by the target audience. However, due to the small sample size recruited for this evaluation, the findings may not be generalized to the target audience as a whole. Furthermore, no 1st or 2nd-year students participated in the evaluation, which means there will be a lack of insight featured in the results relevant to these students in the target group. The use of questionnaires as a data collection method can also be restrictive, and with such a small sample size, it cannot give any representative indication of the target group. Still, it worked well as a backdrop for the evaluation and gave more context to the issues that emerged, such as the problems with controls in the game.

9.5.1 Technical Issues

During the test of the prototype, some technical issues and bugs emerged. The students with Intel-based Macs had significant performance issues, which made the game lag, and may have impacted their overall experience. The game was still playable, but the movements were slowed down and jittery, and some keyboard inputs worked less well. The student with the most severe performance issues was able to borrow the facilitator's Mac which did not have these issues and switched fairly early in the evaluation. Still, the other student experienced issues throughout the evaluation. The prototype had not been tested with an Intel-based Mac in the pilot evaluation described in Section 8.1, and thus these problems had not been discovered before the final evaluation. The rest of the students on the other hand did not experience any significant performance issues. The root of the issues remains to be understood.

Another technical issue was the disappearing mouse pointer. This issue was also found in the pilot test detailed in Section 8.1, although the origin of the issue was not the same. The problem generated some frustration from the affected participants, especially since they had to restart the game. This can therefore also have impacted the overall game experience and results of the evaluation.

9.5.2 Engagement Aspects

The game elements viewed as engaging were collaboration, escape room feeling, and puzzles. Even though the students found some of the elements of the game unclear, and the puzzle difficult to solve, they all reported enjoying the game experience. This was in part due to being two together, which pushed them to continue despite feeling frustrated at times. Both playing in the past and the future were viewed as engaging and interesting in different ways. The past where viewed as particularly engaging due to the conversations with the NPCs which continued the storyline, while the future was intriguing based on its aesthetics and overall dystopic feeling. It can therefore be beneficial to continue to make sure that there is a balance between the game experience on both ends and ensuring that both players have as equal feelings of engagement as possible. The participants also

found the storyline and sustainability theme engaging and thought the use of a dystopic future scenario was appropriate and added to the enjoyment of the game.

9.5.3 Learning Aspects

The students all expressed that they had gained a new perspective and understanding of the connection between sustainability and IT after playing the game. They had many interesting thoughts about how the game experience impacted their views, and the results indicate that the game overall developed more understanding of sustainability and IT and the consequences that IT systems have on sustainability. On the other hand, due to the confusion regarding the information paper on SusAF and the SusAD, the perceived learning about *the five sustainability dimensions* and *the orders of effect* was low. The students reported that it was not easily understood how they could be used as assets in the game. Several of the students found it tedious to explain the diagrams to each other and wanted to wait until it became more obvious that they needed them to proceed. This aligns with the worries expressed by the sustainability expert during the evaluation described in Chapter 8. A way to amend this issue could be to give instructions about the framework before playing the game, although the students were more eager to suggest incorporating it into a puzzle in the game where the use and details can be clarified. This could push the players to examine them more. Although one student thought it should be distributed equally to both players, another thought it was good to separate the papers to motivate collaboration. One student found the content difficult to understand, and several students thought it would be nice to shorten the text. However, a risk of condensing the information might be to further obscure the meaning so this should be carefully considered.

Several of the students expressed that they felt a greater responsibility in how they conducted their work in the future and that they would be more careful in what types of projects they agreed to work on. This can indicate that the game had an impact on the student's perception of their responsibility as IT practitioners. On the other hand, the questionnaire distributed before the evaluation showed that most of the students already highly agreed that they have a responsibility for the systems they are making. The results also show that they thought sustainability should be a priority consideration in IT projects. The students recruited for this evaluation may therefore have been particularly inclined to react in this way to the game experience. Nevertheless, the questionnaire also revealed that they disagreed that sustainability had been a priority in previous projects. This could indicate that even though they agree that sustainability is important, it has not translated into their actions. Future studies investigating how the game can affect IT students in the long term may therefore be interesting to see whether the game experience can impact their future actions as IT practitioners.

Chapter 10

Discussion

This chapter presents a discussion of the results from the different evaluations in this thesis. The data gathered from the evaluations described in Chapter 6, 8, and 9 will be compared, drawing parallels to the related literature found in Chapter 3.

Throughout this project, SustainIT has evolved from a set of learning goals and game elements found in Chapter 3 to a game concept in Chapter 5 and finally, an implemented prototype of a collaborative serious game to teach sustainability and IT to IT students in Chapter 7. The game has been evaluated by a game expert, a sustainability expert, an expert in sustainability and IT, and students from the target audience in Chapter 6, 8, and 9. Each chapter detailing an evaluation done in this thesis already has a discussion section that further reflects upon the results. Therefore, the discussion in this chapter will be focused on comparing the different results of the study as a whole.

10.1 The Potential of Collaborative Serious Games Teaching Sustainability and IT

This thesis has probed the potential for using a collaborative serious game to support teaching about the connection between sustainability and IT. The preparatory project detailed in Chapter 2 presented findings revealing that although IT in many ways provides positive contributions toward sustainability, there are also multiple ways in which IT is part of the problem [16]. Furthermore, studies indicate that there is a need to strengthen the education on sustainability in the computing curriculum, but that so far the development has been slow, partly due to different hindrances the educators experience [1]. The results of this research further support these findings. The sustainability expert interviewed in Chapter 6 had similar views on the problem of introducing sustainability to the curriculum, and further elaborated that she thought major hindrances lay within the educators' available time and resources to implement sustainability in their courses. She also noted that finding a meaningful way to incorporate these topics in different courses can be challenging and that there is a risk of leaving the students feeling it is irrelevant to their studies. The IT student interviewed in Chapter 6 and some of the students participating in the group evaluation in Chapter 9 further reported that they had not had much experience with IT and Sustainability in their studies. On the other

hand, half of the students in the final evaluation reported that they had participated in previous courses where sustainability was connected with IT. Nonetheless, the interview revealed that their experiences in these courses had been limited and that they missed a more holistic approach to the topic. Although the sample size interviewed in this thesis is small, the findings may further contribute with additional insights into the state of education in sustainability and IT.

Previous research has shown that games have the potential to increase engagement and support learning outcomes [11] [32], and collaboration in games has also been found fruitful [14]. Furthermore, the literature reviewed in Chapter 3 revealed that the use of games to teach sustainability has been promising [13], [8], [12], [26], [27], [28], [29], [31]. The findings of this research further confirm that there is enthusiasm toward using games in sustainability education and that a collaborative SG for sustainability and IT can promote learning outcomes and engagement. The experts in IT and sustainability interviewed in Chapter 6 and 8 respectively, were both excited to see these topics put in a game context and thought it could potentially provide value as a learning tool. The latter also saw the potential for incorporating such a game into a course, although it was noted that there should be some arrangements and facilitation planned around the game to fully exploit the learning potential. The students interviewed in Chapter 6 and 9 reasoned that games can be engaging, provide motivation to learn, and make lectures more exciting. Some of the interviewed students also expressed that they miss more use of games and interactivity in lectures, referring to *Kahoot* as an example they have appreciated in the past.

In [13] they recommended future research within sustainability games to look into features that promote holistic learning, integrating realistic 3D graphics and intensifying social interaction. This research addresses all of these recommendations in the game design of SustainIT, and can therefore further contribute to the understanding of SGs as educational tools for sustainability. SustainIT as a game concept was received with much enthusiasm and interest from all participants in this study. The concept has been described as fun, engaging, thought-provoking and creative, and the idea of having two players collaborate across two different times where viewed as an interesting concept that lay a nice foundation for an engaging experience that supports learning about the different impacts of IT. The results of the final evaluation with students in Chapter 9 also indicated that the game experience had an impact on their perception and understanding of sustainability and IT, and they reported that they felt more motivated to consider sustainability in their future endeavors as IT practitioners. Some of the participants also noted that they felt the game provided a more holistic view of sustainability and IT. Nonetheless, the purpose of the evaluations conducted in this research has not been to evaluate the actual learning outcomes and changes in perception, but rather to indicate the potential in supporting the learning goals detailed in Table 2.3. Further research into the learning outcomes, changes in perceptions, and how this may translate into action should therefore be conducted to give more clear indications in this respect. The results of the final evaluation with the sustainability and IT expert and IT students in Chapter 8 and 9 also indicated that the game could both be valuable in the first years of university as well as being introduced later. A general opinion was that the earlier the students

were exposed to the topics presented in the game, the better.

10.2 Game Elements

In Chapter 3 previous research was reviewed to inform the collection of suitable engaging game elements for the game to be designed, which can be seen in Table 3.2. A subset of these elements was then utilized in the chosen game concept, which is further elaborated upon in Chapter 5. The results of the evaluations in Chapter 6, 8 and 9 revealed that several of the game elements were perceived as motivational and engaging, which therefore can further support the findings in [32], [35], [34], [39]. Collaboration, storyline, and puzzles were particularly emphasized as the most engaging elements and strengths of the game. The game expert emphasized that a strong narrative and collaboration both were compelling features that support engagement. In the final evaluation with students, they saw the collaborative aspect as a necessary element of the game, commenting that it pushed them to go further in the game despite their frustrations with certain aspects. Other aspects that were pointed out as engaging were the escape-room feeling and mystery aspect, and the use of dystopic future scenarios, which tied in well with the storyline puzzle element. Finally, being able to make decisions that would affect the game environment also came up in multiple evaluations as an aspect that was engaging, thus making consequential play another promising game element. These findings help indicate a set of effective game elements to promote motivation and engagement in a collaborative SG to teach sustainability and IT. However, these have only been evaluated and tested for the specific game concept that was designed in this study, and may not have the same effect in other types of collaborative SGs with the same learning purposes.

Collaboration was also brought up as a beneficial element for learning, as this can support discussion and reflection, as well as aid problem-solving. Furthermore, the advice sentence mechanic was pointed out as a crucial element for learning since this can help structure the discussion process and make connections between the decisions and the resulting impacts. The context of the game where the players can see the impacts of an IT project in the past and the future was also seen as a promising component to further learning about sustainability and IT.

Parts of the SusAF framework further detailed in Chapter 3 were included in the game as an optional tool to inform the choice of advice sentences as a result of the evaluation in Chapter 6. The study can therefore further contribute to the understanding of how this framework can be used in teaching. In [4] it was argued that students could use the framework on their own without previous experiences with it, although not entirely without introduction. The sustainability and IT expert in Chapter 8 were on the other hand more curious to see if the students could make the connection to how the framework may be used in the game without a presentation beforehand. She further noted that the framework has traditionally been incorporated into a workshop where the participants are introduced to the framework and shown examples. The results of the final evaluation with IT students in Chapter 9 revealed that the participants did not intuitively understand how they could utilize the given information related to SusAF, which indicates

that the incorporation of SusAF would need strengthening for it to add to the learning outcomes. The participants further suggested that they thought it could be helpful to integrate the framework and the information related to it in the game, by for example explicitly using it in a puzzle, to further push the player to try to understand and interact with it. If SustainIT were incorporated in a lecture it could also be helpful to begin with an introduction to the topic of sustainability and IT before letting the students play the game, as recommended by the sustainability and IT expert in Chapter 8. This could be interesting to test out in a future iteration of the game, or in other endeavors to teach the SusAF.

10.3 Learning Goals

In Chapter 2, a set of learning goals for the game was proposed based on the reviewed literature in the preparatory project, which can be seen in Table 2.3. Furthermore, Chapter 3 examined relevant studies to inform the use of game elements to support these goals. The game elements included in the game concept are further detailed in Section 5.4.

Previous research highlights that IT students should learn systems thinking [1], [8]. This was therefore included as a learning goal for the game of this study, and the findings in the evaluations could indicate a potential for teaching systems thinking through a collaborative SG. The sustainability expert who evaluated the initial concept in Chapter 6 thought the game could help learn systems thinking through creating advice sentences and then seeing the resulting impacts, provided that these were well connected. The sustainability and IT expert interviewed in Chapter 8 slightly agreed that it could promote systems thinking, although she thought the game should emphasize the complexity of IT and sustainability even more. The participants in the evaluation described in Chapter 9 expressed that the game provided them with a wider perspective on IT and sustainability and that they learned that their decisions can have different impacts. However, the research in this project is still too limited to determine whether the game is successful in this specific learning goal. More research and further development of the prototype would be needed to understand how well the game works in this aspect.

Furthermore, previous research has emphasized that it is important to communicate the importance of sustainability and IT and make IT practitioners, and thereby IT students, recognize their responsibility to address these issues in their work [1], [2], [3]. The sustainability and IT expert interviewed in Chapter 8 thought that the game had the potential for making the students more aware of the issues surrounding sustainability and IT, and noted that any attempts to push the students' reflection around sustainability and IT would be useful. She further elaborated that it would be important for the students to make the connection between the decisions made in the past, with the different future scenarios. After the test of the prototype in Chapter 9, the students agreed that they felt more compelled to consider sustainability in their choice of work and their projects in the future. Nonetheless, the questionnaire distributed beforehand revealed an overall high agreement with the importance of considering sustainability in IT systems among the participants. The recruited students might therefore have been

more inclined to understand the importance of sustainability and IT in the first place. On the other hand, an interesting finding was how low they scored the second statement "*Sustainability has been a priority consideration in my previous IT projects*" compared to the rest of the statements. This could suggest that although the students already have an understanding of the importance of sustainability and IT, they have so far not applied this in their practice. Nevertheless, it is difficult to know if the game experience will have any long-lasting impact on the students, by making them more likely to consider sustainability in their future projects. It could therefore be valuable to examine the long-term effects of collaborative SGs for sustainability and IT to make IT students compelled to address sustainability in their work and recognize their responsibility as IT practitioners. Research featuring a larger and more diverse amount of participants from the target group would also be needed to give any representative results.

Chapter 11

Conclusion

This chapter will present the conclusion of the study, by summarizing the results of the research, detailing the strengths and limitations, and finally giving recommendations for future work.

11.1 Summary of Results

This research contributes to the area of serious games on sustainability and IT. The main contributions can be found in the State of the Art in Chapter 3, the expert evaluations of the concept in Chapter 6, the implementation of the prototype in Chapter 7, and the final evaluations of SustainIT in Chapter 8, 9 and 10.

By examining previous research in the preparatory project, it was found that IT can both support sustainability and be a contributor to the problem. There is therefore a need for IT practitioners that are both educated in systems thinking and sustainability, who recognize their responsibility to address these issues. However, sustainability education in computing has been slow to emerge. This study therefore designed and evaluated a prototype of the game SustainIT, to investigate the potential of a collaborative SG to teach sustainability and IT and challenge their perception of this topic.

11.2 Research Questions

The research questions of this study will be addressed and answered in this section.

RQ1: How can a collaborative serious game be designed to develop knowledge about IT and sustainability among IT students, and challenge their perception of the topic?

This research aimed to explore how a collaborative serious game could be designed to develop IT students' knowledge about the connection between sustainability and IT. Furthermore, the aim was to challenge IT students' perceptions of the topic. The game concept SustainIT has therefore been designed, evaluated at different stages and tested by participants from the target audience, which have been thoroughly documented throughout this thesis. Combining the various assessments of the game concept indicates that

it indeed has the potential as a learning tool for developing IT students understanding and perception of sustainability and IT. The main research question is further answered through a set of sub-questions.

RQ1.1: How can learning elements be used in a collaborative serious game to teach sustainability and IT, and challenge students' perception of this topic?

The literary research done in the preparatory project prior to this study, which is further detailed in Chapter 2, identified that students in IT should learn about systems thinking and understanding the impacts of IT, as well as understand their responsibility as IT practitioners. In Chapter 3, a review of recommendations for teaching these aspects was therefore performed to inform the learning elements of the game. The evaluations done by experts revealed a high interest in the advice sentence mechanic and the resulting effects. Furthermore, the expert in sustainability and IT interviewed in Chapter 8 thought that the inclusion of SusAF could bring novel insights into the learning and use of this framework. The results of the test performed with participants from the target audience indicate that the game experience resulted in new revelations about the impacts of IT on sustainability and that it overall had an effect on the students' perceptions of IT and sustainability. The findings do however also show that certain learning elements such as the inclusion of SusAF need to be strengthened to exploit its full learning potential. The use of narrative and storyline featuring a dystopic future scenario based on decisions made in the past was also seen as a strong component for challenging the perception of sustainability and IT.

RQ1.2: What kind of game elements can be used in a collaborative serious game to motivate and engage students in learning about sustainability and IT?

In Chapter 3, literature on motivational and engaging game elements relevant to this study was explored, to inform the conceptualization and design of the game in this research. This resulted in a collection of engaging game elements and corresponding design principles, which inspired three game concepts detailed in Chapter 4. A comparison of these concepts led to the choice of the final concept that has been designed and evaluated. The findings of this study revealed that collaboration, storyline, and puzzles were viewed as the most engaging elements used in SustainIT. The division of the players into two different times, past and future, as well as the escape-room-esque feeling of the puzzle, were seen as supporting aspects of these elements. Furthermore, decision-making and seeing the resulting consequences of these decisions were also deemed as engaging aspects.

11.3 Strengths and Limitations

The strength of the study is the triangulation of data through multiple evaluations with different actors throughout this project, which has helped improve the validity of the findings. The game concept and the implemented prototype have been evaluated by gathering qualitative data through interviews and observations. These evaluations have helped strengthen the game concept in terms of engagement and learning and helped

ensure it met its purpose as a learning tool. On the other hand, a limitation of the study is that the final prototype has been tested by a small sample size of the target audience, 6 participants in total, which will not be able to represent the group as a whole. It is therefore difficult to draw any strong conclusions based on the findings. There may be perspectives that have not come to light in the evaluations, which could have vital implications for the game. Conducting further research with a larger sample size of the target audience will help provide a further generalization of the findings exhibited in this study.

Another limitation is that the research has only assessed the initial effect of the game experience provided by the implemented prototype, as the available time and resources of this study did not allow for studying the long-term effect of the game. The data gathered from the test with the target audience can therefore only give insight into the perceived learning and impact of the game experience. Accordingly, it is not possible to conclude the long-term effects of the game based on the findings of this study.

Because of the limited resources and time available in this project, it was not feasible to develop the game concept into a fully-fledged prototype. The implemented prototype described in Chapter 7 only featured a minimal viable product of the game concept, and some of the critical features were missing, such as the visualization of effects based on input advice sentences. These features have therefore only been considered by the participants of this study in theory, and have not been tested through a game context. This may in turn have altered the participants' perception and understanding of these elements. It is therefore difficult to conclude whether a finished implementation of SustainIT with these features would work well, and if these features would elicit the same response.

The nature of the game does not lend itself to easy customization and alteration, which may be viewed as a weakness. Any changes to the prototype would require further game development, which in turn requires experience and knowledge in Unity. This can limit the usage of the game in the computing curriculum, as it might not fit well within any given course. On the other hand, this can also be viewed as a strength, since the game may be more tailored towards teaching the specific learning goals specified in this project.

11.4 Recommendations for Future Work

There are several ways to continue the work done in this master's thesis. The implemented prototype of SustainIT still only shows a limited version of the game and can benefit greatly from being expanded upon. Critical features were missing in the prototype that should be added in future iterations which are described further in Section 7.2.3. Furthermore, the final evaluations of the prototype revealed shortcomings in the game and yielded helpful feedback that can be used to address these issues. Adding more cases to explore in the game could also be interesting, to reveal other types of impacts of IT on sustainability in the game. It would be beneficial to conduct more research into examples of IT systems with serious implications on sustainability to connect the puzzles and events in the game with literature describing real-world scenarios of IT solutions, and their sustainability impacts. Research comparing the students' reactions and learning

outcomes from each case could then be performed, to learn more about what types of sustainability impacts elicit a bigger change in the perception of sustainability and IT.

SustainIT should also be evaluated and tested with a larger population from the target audience, to get a better understanding of whether the learning and game elements work well for the group as a whole. Such evaluations may also bring further insights into how the game concept can be strengthened. Further research should also look at the long-term effects of playing SustainIT, to indicate whether the game experience can increase students' knowledge and change students' perceptions and attitudes toward sustainability and IT over time. Testing the game in a lecture or other learning context facilitated by a teacher could also provide valuable insights into how SustainIT works in such environments, and further validate the potential of collaborative serious games to teach sustainability and IT.

It could also be interesting to explore the possibility of an interdisciplinary version of the game, with students from other disciplines working on IT solutions such as interaction designers or entrepreneurs, or even other disciplines more far removed from the field of IT. The amount of people who either have a say in the design of IT systems or are affected by them is vast, and it can be valuable to extend the range of people learning about the connection between IT and sustainability. Seeing that digitalization is touching upon all sectors of society in some way, this knowledge can be beneficial and valuable to all.

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Appendix A

Approval for Data Collection



[Meldeskjema](#) / [Collaborative games for IT and Sustainability](#) / Vurdering

Vurdering av behandling av personopplysning

Referansenummer

463440

VurderingstypeAutomatisk **Prosjekttittel**

Collaborative games for IT and Sustainability

Behandlingsansvarlig institusjon

Norges teknisk-naturvitenskapelige universitet / Fakultet for informasjonsteknologi og elektroteknikk (og informatikk

Prosjektansvarlig

Monica Divitini

Student

Benedicte Helen Myrvoll

Prosjektperiode

01.02.2023 - 28.06.2023

Kategorier personopplysninger

Alminnelige

Lovlig grunnlag

Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet og gjelder til 28.06.2023.

[Meldeskjema](#) 

Grunnlag for automatisk vurdering

Meldeskjemaet har fått en automatisk vurdering. Det vil si at vurderingen er foretatt maskinelt, basert inn i meldeskjemaet. Kun behandling av personopplysninger med lav personvernulempe og risiko får automatisk godkjenning. Kriterier er:

- De registrerte er over 15 år
- Behandlingen omfatter ikke særlige kategorier personopplysninger;

- Hvor lenge personopplysningene vil bli behandlet
- Retten til å trekke samtykket tilbake og øvrige rettigheter

Vi anbefaler å bruke vår [mal til informasjonsskriv](#).

Informasjonssikkerhet

Du må behandle personopplysningene i tråd med retningslinjene for informasjonssikkerhet og lagrings- og behandlingsansvarlig institusjon. Institusjonen er ansvarlig for at vilkårene for personvernforordningen, integritet og konfidensialitet, og 32 sikkerhet er oppfylt.

Appendix B

Information Letters Distributed to Participants

Are you interested in taking part in the research project

“Collaborative games for IT and sustainability”?

You are invited to participate in a research project where the main purpose is to create an educational game for students within IT, to increase their awareness and knowledge of the connection between sustainability and IT. In this document, we provide you with information about the aims of the project and what participation will mean for you.

Purpose of the project

In this project, the research is done within the topic of sustainable IT and how IT students can learn about it. The IT field has an important role when it comes to supporting sustainability and addressing the climate challenges we face today. On the other hand, IT solutions also have the potential to contribute to these problems, and in the long run worsen the situation. IT students who are going to eventually work on such solutions should therefore have knowledge of these challenges, so that they can make conscious decisions in their future projects. The aim of the project is therefore to create a multiplayer educational game where students can increase their awareness and knowledge of how IT solutions can have both positive and negative impacts on sustainability.

The project is carried out in connection with the master's thesis of Benedicte Helen Myrvoll. The master's project is carried out under the Department of Computer Science (IDI) at NTNU and was started on the 1st of February 2023 and will be completed on the 28th of June 2023. The information collected will not be used for purposes other than this master's thesis.

Which institution is responsible for the research project?

The Department of Computer Science (IDI) at Norwegian University of Science and Technology (NTNU) is responsible for the project (data controller).

Why are you being asked to participate?

You are invited to participate in this project because you have expertise in game design. I believe it gives you the ability to assess the game concept I have created in the project, and that you can bring valuable insight into how the game can be further designed to be engaging and entertaining for the players. Your contact information is taken from the supervisor's network.

What does participation involve for you?

If you choose to participate in the project, it means that you participate in an interview that will last approximately 45 minutes. During the interview, I show sketches and a description of the concept for the game I am going to make. You will then be asked about your thoughts on the layout and design of the game, and to share any constructive feedback you may have. During the interview, I take audio recordings and notes. The interview is conducted digitally.

Participation is voluntary

Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified here and we will process your personal data in accordance with data protection legislation (the GDPR). Only the student in the project will have access to the audio recording and the notes from the interview. These will be transcribed and anonymized, and I will replace your name and contact details with a code that will be stored on a separate name list separate from other data. Except for the audio recordings and information necessary to contact the participants, no personal information about the participants will be collected.

The audio recordings will be uploaded to a computer connected to the NTNU network with password protection for transcription. The data will be stored on a password-protected server at NTNU SharePoint. The supervisor of the project will have access to parts of the anonymized data. Participants will not be able to be recognized in the final master's thesis.

All personal data and audio recordings will be deleted at the end of the project (June 2023).

What will happen to your personal data at the end of the research project?

The planned end date of the project is 28th of June 2023. After the end of the project, the data material with your personal information will be deleted.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with NTNU, The Data Protection Services of Sikt – Norwegian Agency for Shared Services in Education and Research has assessed that the processing of personal data in this project meets requirements in data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- The Department of Computer Science (IDI) via Monica Divitini. Email: divitini@ntnu.no
- Student Benedicte Helen Myrvoll. Email: benedihm@stud.ntnu.no
- Our Data Protection Officer: Thomas Helgesen. Email: thomas.helgesen@ntnu.no or by telephone: 93 07 90 38

If you have questions about how data protection has been assessed in this project by Sikt, contact:

- email: (personverntjenester@sikt.no) or by telephone: +47 73 98 40 40.

Yours sincerely,

Monica Divitini
Project Leader
(Researcher/supervisor)

Benedicte Helen Myrvoll
Student

Consent form

I have received and understood information about the project “Collaborative games for IT and sustainability” and have been given the opportunity to ask questions. I give consent:

to participate in an interview

I give consent for my personal data to be processed until the end of the project.

(Signed by participant, date)

Are you interested in taking part in the research project

“Collaborative games for IT and sustainability”?

You are invited to participate in a research project where the main purpose is to create an educational game for students within IT, to increase their awareness and knowledge of the connection between sustainability and IT. In this document, we provide you with information about the aims of the project and what participation will mean for you.

Purpose of the project

In this project, the research is done within the topic of sustainable IT and how IT students can learn about it. The IT field has an important role when it comes to supporting sustainability and addressing the climate challenges we face today. On the other hand, IT solutions also have the potential to contribute to these problems, and in the long run worsen the situation. IT students who are going to eventually work on such solutions should therefore have knowledge of these challenges, so that they can make conscious decisions in their future projects. The aim of the project is therefore to create a multiplayer educational game where students can increase their awareness and knowledge of how IT solutions can have both positive and negative impacts on sustainability.

The project is carried out in connection with the master's thesis of Benedicte Helen Myrvoll. The master's project is carried out under the Department of Computer Science (IDI) at NTNU and was started on the 1st of February 2023 and will be completed on the 28th of June 2023. The information collected will not be used for purposes other than this master's thesis.

Which institution is responsible for the research project?

The Department of Computer Science (IDI) at Norwegian University of Science and Technology (NTNU) is responsible for the project (data controller).

Why are you being asked to participate?

You are invited to participate in this project because you have expertise in sustainability. I believe it gives you the ability to assess the content and learning goals in my game concept, and that you can bring valuable insight into how the game concept can be further developed to increase awareness and knowledge about sustainability and IT. Your contact information is taken from the supervisor's network.

What does participation involve for you?

If you choose to participate in the project, it means that you participate in an interview that will last approximately 45 minutes. During the interview, I show sketches and a description of the concept for the game I am going to make. You will then be asked about your thoughts on education in sustainability and IT, and to share any constructive feedback you may have for the content, learning objectives and design of the game. During the interview, I take audio recordings and notes. The interview is conducted digitally.

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Vil du delta i forskningsprosjektet

“Collaborative games for IT and sustainability”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å lage et læringsspill for studenter innen IT, for å øke deres bevissthet og kunnskap om sammenhengen mellom bærekraft og IT. I dette skrevet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

I dette prosjektet forskes det på bærekraftig IT, og hvordan IT-studenter kan lære om dette temaet. IT-fagfeltet har en viktig rolle når det kommer til å støtte opp om bærekraftighet og adressere klimautfordringene vi står ovenfor i dag. IT-løsninger har på den andre siden også potensiale til å bidra til disse problemene, og på sikt forverre situasjonen. IT-studenter som skal ut i arbeidslivet bør derfor ha kunnskap om disse utfordringene, slik at de kan ta veloverveide valg i sine fremtidige prosjekter. Målet med prosjektet er derfor å lage et flerspiller læringsspill der studentene får økt bevissthet og kunnskap om hvordan IT-løsninger kan ha både positive og negative innvirkninger på bærekraft.

Prosjektet gjennomføres i sammenheng med masteroppgaven til Benedicte Helen Myrvoll. Masterprosjektet gjennomføres under institutt for datateknologi og informatikk ved NTNU, og er startet opp 1. februar 2023 og fullføres 28. juni 2023. Opplysningene som hentes skal ikke benyttes til andre formål enn denne masteroppgaven.

Hvem er ansvarlig for forskningsprosjektet?

Institutt for datateknologi og informatikk (IDI) ved Norges teknisk-naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?

Du er invitert til å delta i dette prosjektet fordi du studerer IT på universitetsnivå. Jeg mener det gir deg evnen til å kunne vurdere innholdet og utformingen av spillprototypen jeg skal utvikle i prosjektet, og at du kan bidra med verdifulle tilbakemeldinger på hvordan spillet kan videre utformes for å bidra til mer engasjement og motivasjon for å lære om bærekraft og IT. Kontaktinformasjonen din er hentet fra eget nettverk.

Hva innebærer det for deg å delta?

Dersom du velger å delta i prosjektet, innebærer det at du deltar i et intervju som vil vare i ca. 45 minutter. Under intervjuet vil du få spørsmål om dine tanker om bærekraft og IT, og bli vist skisser av spillet jeg skal lage. Du vil deretter få spørsmål om dine tanker om skissene og eventuelle tilbakemeldinger. Under intervjuet tar jeg lydopptak og notater. Intervjuet gjennomføres digitalt.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Det er kun studenten i prosjektet som vil ha tilgang til lydopptaket og notatene fra intervjuet. Disse vil bli transkribert og anonymisert, og navnet og kontaktopplysningene dine vil jeg erstatte med en kode som lagres på egen navneliste adskilt fra øvrige data. Med unntak av lydopptakene og informasjon nødvendig for å kontakte deltakerne, vil ingen personlig informasjon om deltakerne samles inn.

Lydopptakene vil kunne bli lastet opp på datamaskin tilkoblet NTNU-nettverk med passordbeskyttelse for transkribering. Dataene vil bli lagret på en passordbeskyttet server på NTNU Sharepoint. Veileder av prosjektet vil ha tilgang til deler av den anonymiserte dataen. Deltakere vil ikke kunne gjenkjennes i den endelige masteroppgaven. Alle personopplysninger og lydopptak skal slettes ved prosjektslutt (juni 2023).

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?

Prosjektet vil etter planen avsluttes 28. juni 2023. Etter prosjektslutt vil datamaterialet med dine personopplysninger slettes.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra NTNU har Sikt – Kunnskapssektorens tjenesteleverandør vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

Hvis du har spørsmål til studien, eller ønsker å vite mer om eller benytte deg av dine rettigheter, ta kontakt med:

- Veileder: Monica Divitini. Epost: divitini@ntnu.no
- Student: Benedicte Helen Myrvoll. Epost: benedihm@stud.ntnu.no
- Vårt personvernombud: Thomas Helgesen. Epost: thomas.helgesen@ntnu.no eller telefon: 93 07 90 38

Hvis du har spørsmål knyttet til vurderingen som er gjort av personverntjenestene fra Sikt, kan du ta kontakt via:

- Epost: personverntjenester@sikt.no eller telefon: 73 98 40 40.

Med vennlig hilsen

Monica Divitini
(Forsker/veileder)

Benedicte Helen Myrvoll

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «*Collaborative games for IT and sustainability*», og har fått anledning til å stille spørsmål. Jeg samtykker til:

å delta i intervju

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

(Signert av prosjektdeltaker, dato)

Vil du delta i forskningsprosjektet

“Collaborative games for IT and sustainability”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å lage et læringsspill for studenter innen IT, for å øke deres bevissthet og kunnskap om sammenhengen mellom bærekraft og IT. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

I dette prosjektet forskes det på bærekraftig IT, og hvordan IT-studenter kan lære om dette temaet. IT-fagfeltet har en viktig rolle når det kommer til å støtte opp om bærekraftighet og ta hensyn til klimautfordringene vi står ovenfor i dag. IT-løsninger har på den andre siden også potensiale til å bidra til disse problemene, og på sikt forverre situasjonen. IT-studenter som skal ut i arbeidslivet bør derfor ha kunnskap om disse utfordringene, slik at de kan ta veloverveide valg i sine fremtidige prosjekter. Målet med prosjektet er derfor å lage et flerspiller læringsspill der studentene får økt kunnskap om hvordan IT-løsninger kan ha både positive og negative innvirkninger på bærekraft, og endret sine holdninger i forhold til bærekraft og IT.

Prosjektet gjennomføres i sammenheng med masteroppgaven til Benedicte Helen Myrvoll. Masterprosjektet gjennomføres under institutt for datateknologi og informatikk ved NTNU, og er startet opp 1. februar 2023 og fullføres 28. juni 2023. Opplysningene som hentes skal ikke benyttes til andre formål enn denne masteroppgaven.

Hvem er ansvarlig for forskningsprosjektet?

Institutt for datateknologi og informatikk (IDI) ved Norges teknisk-naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?

Du er invitert til å delta i dette prosjektet fordi du har kompetanse innenfor bærekraft og IT. Jeg mener det gir deg evnen til å kunne vurdere innholdet og læringsmålene i spillkonseptet jeg har laget i prosjektet, og at du kan bidra med verdifull innsikt i hvordan spillet kan videre utformes for å være bidra til å endre holdninger og økt kunnskap om bærekraft og IT. Kontaktinformasjonen din er hentet fra veileder sitt nettverk.

Hva innebærer det for deg å delta?

Dersom du velger å delta i prosjektet, innebærer det at du deltar i et intervju som vil vare i ca. 45-60 minutter. Under intervjuet viser jeg frem spillprototypen jeg har laget. Deretter vil du få spørsmål om dine tanker om undervisning innen bærekraft og IT, og eventuelle konstruktive tilbakemeldinger du måtte ha når det kommer til innholdet og utformingen av spillet. Under intervjuet tar jeg lydopptak og notater. Intervjuet gjennomføres digitalt.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Det er kun studenten i prosjektet som vil ha tilgang til lydopptaket og notatene fra intervjuet. Disse vil bli transkribert og anonymisert, og navnet og kontaktopplysningene dine vil jeg erstatte med en kode som lagres på egen navneliste adskilt fra øvrige data. Med unntak av lydopptakene og informasjon nødvendig for å kontakte deltakerne, vil ingen personlig informasjon om deltakerne samles inn.

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Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?

Prosjektet vil etter planen avsluttes 28. juni 2023. Etter prosjektslutt vil datamaterialet med dine personopplysninger slettes.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

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(Signert av prosjektdeltaker, dato)

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Hva innebærer det for deg å delta?

Dersom du velger å delta i prosjektet, innebærer det at du deltar i en spillevaluering og intervju som vil vare i ca. 90 minutter. Du vil først bli bedt om å teste spillprototypen sammen med en meddeltaker, og deretter vil du bli intervjuet sammen med resten av deltakerne. Under intervjuet vil dere få spørsmål om deres tanker om spillet og om bærekraft og IT. Dere vil også få mulighet til å gi tilbakemeldinger på utformingen av prototypen og læringsutbytte. Under intervjuet tar jeg lydopptak og notater. Intervjuet gjennomføres fysisk.

Det er frivillig å delta

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Med vennlig hilsen

Monica Divitini

Benedicte Helen Myrvoll

(Forsker/veileder)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «*Collaborative games for IT and sustainability*», og har fått anledning til å stille spørsmål. Jeg samtykker til:

- å delta i intervju

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

(Signert av prosjektdeltaker, dato)

Appendix C

Interview Guides

Interview Guide - Concept Evaluation with Game Expert

Concept

1. What is important in games that promote cooperation?
2. What do you think about the narrative element described in the concept?
3. What do you think about the game design described in the concept?
4. What do you think about the mechanics described in the concept?
5. How about the learning element?
6. What are the strengths of the concept?
7. What are the weaknesses of the concept?
8. Does the concept work for this target group?
9. What should be added or possibly changed to make the gaming experience more engaging?
10. Which elements can strengthen cooperation between the players?
11. Which elements can increase motivation and learning?
12. What challenges can arise in the development of such a game?

Interview Guide – Concept Evaluation with Sustainability Expert

Sustainability and IT education

1. How is knowledge about sustainability taught and communicated in higher education in technical studies today?
2. What are usually the shortcomings when it comes to incorporating sustainability in higher education?
3. How can collaboration be useful in teaching about sustainability?
5. What kind of knowledge about sustainability do you think is important to highlight in IT education?

Game concept

7. What do you think about the content described in the concept?
8. What do you think about the narrative element described in the concept?
9. What are the strengths of the concept?
10. What are the weaknesses of the concept?
11. Do you think this concept could help to teach systemic thinking to IT students? Why/Why not?
12. How can the educational aspects be enhanced in your opinion?
12. What do you think about the difficulty level?
13. What types of tasks or projects can you envision in the game?
14. Is there something you miss in the concept?

Interview Guide – Concept Evaluation IT Student

Generelt om Bærekraft og IT

1. Hva tenker du på når du hører ordet bærekraft?
2. Har du hatt fag der temaet bærekraft har blitt tatt opp på studiet ditt?
 - a. I såfall, hva lærte du om der?
3. Hva er dine tanker om hvordan bærekraft og IT henger sammen?
4. Hva dukker opp i dine tanker når du hører bærekraftig IT?
5. Har du et ønske om å lære mer om sammenhengen mellom bærekraft og IT?
Hvorfor/Hvorfor ikke?

Prototypen

6. Spiller du på fritiden?
7. Hva tenker du om å bruke spill i undervisning på universitetet?
8. Hva synes du om å måtte samarbeide i spill?
9. Hvilke tanker har du om innholdet i spillet?
10. Hva synes du om fortellings-elementet i spillet?
11. Hva tenker du om det du skal lære i spillet?
12. Hva synes dere om vanskelighetsgraden?
13. Tror du dette spillet kunne vært nyttig for deg for å lære mer om bærekraft og IT? Hvorfor/Hvorfor ikke?
14. Hvilke elementer liker du best i spillet?
15. Er det noen elementer i spillet du er usikker på eller som du tror vil fungere dårligere?
16. Hva kunne gjort spillet mer engasjerende og morsomt for deg?
17. Er det noe du savner i spillet?

Interview Guide – Final Evaluation with Sustainability and IT Expert

Spillprototypen

1. Hva synes du om spillet?
2. Var spillet interessant?
3. Hva synes du om historie-elementet?
4. Hva synes du om samarbeidsaspektet?
5. Hva tenker dere om spillelementene?
 - Hva var morsomst?
 - Hva var engasjerende?
6. Hva tenker du om å gjemme de ulike informasjonsbitene i puzzles, dialog og spillelementer, og la studentene koble det sammen selv?
7. Hva synes du om «Råd» mekanikken?
8. Hva synes du om å vise effektene av rådene?
9. Hva likte du best med spillet
10. Hva likte du minst?
11. Hva synes du om vanskelighetsgraden?
12. Var det noe som var uklart eller vanskelig å forstå?
13. Forslag til forbedringer?

Læring

14. Er innholdet i spillet relevant for å lære IT student om bærekraft og IT?
15. Hva synes du om bruken av SusAF?
16. Hvilke elementer mener du styrker læringen?
17. Tror du spillet kan bidra til å øke IT-studenters kunnskap om bærekraft og IT, og ITs innvirkning på bærekraft? Hvorfor/ hvorfor ikke?
 - Hvilke elementer tror du bidrar mest til dette?
18. Tror du spillet kan bidra til å lære IT-studenter systemisk tenkning? Hvorfor/ hvorfor ikke?
 - Hvilke elementer tror du bidrar mest til dette?
19. Tror du spillet kan bidra til å endre studenters holdning til bærekraft og IT? Hvorfor/ hvorfor ikke?
 - Hvilke elementer tror du bidrar mest til dette?
20. Er det noe ved læringsinnholdet som mangler?
21. Hva tenker du om å bruke digitale spill i universitetsundervisning?
22. Tror du det ville vært mulig å bruke et slikt spill i universitetsundervisning? Forelesning/lab/øving?
23. Hvem tror du spillet passer best for med tanke på klassetrinn?

Interview Guide – Group Evaluation with IT Students

Spillprototypen:

1. Hva synes dere om spillet?
2. Var innholdet interessant?
3. Synes dere spillet var underholdende?
4. Var spillet engasjerende?
5. Var noe kjedelig?
6. Hva tenker dere om spillelementene?
 - a. Hva var morsomst?
 - b. Hva var engasjerende?
7. Hva synes dere om historien i spillet?
 - a. Var den engasjerende?
8. Hva synes dere om å være satt i fortiden og fremtiden?
9. Hva syntes dere om å måtte samarbeide i spillet?
10. Hva synes dere om diagrammet og informasjonen om bærekrafts dimensjoner og effekter?
 - a. Så dere sammenhengen mot resten av elementene i spillet?
11. Hva tenker dere om å gjemme de ulike informasjonsbitene i puzzles, dialog og spillelementer, og la spillerne tenke ut råd ut ifra de?
12. Hva synes dere om «Råd» mekanikken?
13. Hva synes dere om vanskelighetsgraden?
14. Var det noe som var uklart eller vanskelig å forstå?
15. Forslag til forbedringer?

16. Læring:

17. Lærte dere noe nytt i spillet eller av hverandre dere ikke kunne fra før?
18. Hva er tankene deres om hvordan bærekraft og IT henger sammen?
19. Er læringsinnholdet i spillet relevant og engasjerende?
20. Hvilket aspekt ved spillet bidro mest til læring for dere?
21. Var det noe i spillet som endret synet deres på bærekraft og IT?
22. Føler dere på mer motivasjon for å ta hensyn til bærekraft i fremtidige prosjekter?
23. Kunne dere tenkt dere å lære mer om bærekraft og IT?
24. Hvem tror dere spillet passer best for?
25. Hva hadde dere syntes om å bruke dette spillet i universitetsundervisning?
 - a. Forelesning/lab/øving?

Appendix D

Storyboards

Storyboard V1



The start screen of the game. Players can choose between loading a previously started game, starting a new game, going into the options menu, or quitting the game.



When the players click start new they are presented with the choice between the past or the future. One player have to pick the past, and the other must pick the future.



In the introduction scene of the game, the players are shown the outside of the office building for an IT company called FuturIT, on a bright summer day.



Inside, employees are busy working by their desks and chatting with their colleagues, and seemingly very happy and enthusiastic about their jobs. The company is very successful, and is the main provider of IT-solutions for the country.



The new CEO of the company, Thomas Tech, can be seen in the next shot, smiling widely and looking somewhat smug while watching his employees. He is very happy with his new position, and have great plans in mind for the future of the company.



The camera then zooms in on a person sat at one desk, that is looking somewhat worried at their computer screen.



A ticking noise can be heard in the background, and the shot changes to a clock that is going faster and faster until it stops.



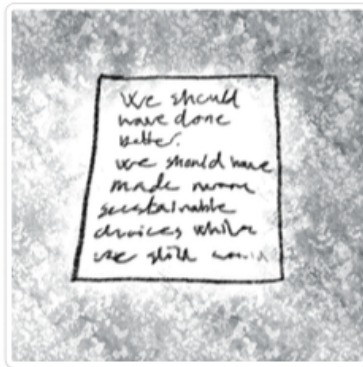
It is now 10 years later. The room is now more dark and gloomy, and the music is more somber.



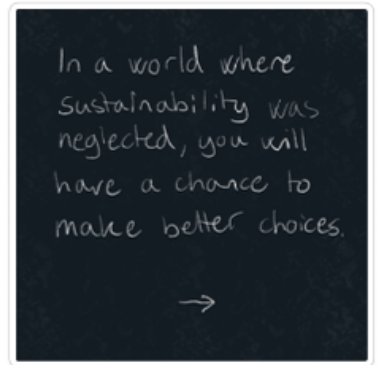
Outside the rain is pouring, and lightning strikes can be seen over a dark and dirty city, that is surrounded by thick fog and pollution. In the foreground, there is a wilted plant.



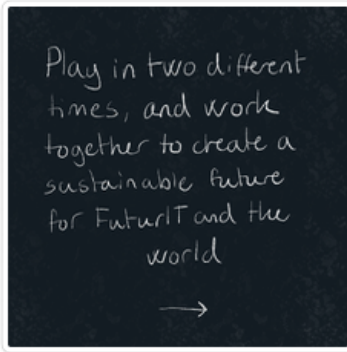
In the next scene, the desk that the worried worker once sat at is in focus, and there is a note on it with shaky letters.



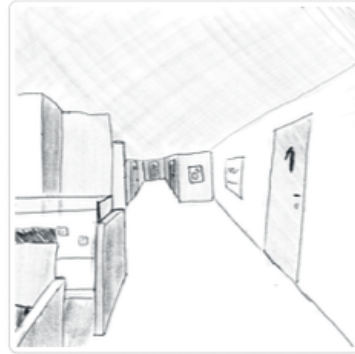
The letter reads: "We should have done better. We should have made more sustainable choices while we still could."



Then, the screen turns black, and there is a message that reads: "In a world where sustainability was neglected, you will have the chance to make better choices."



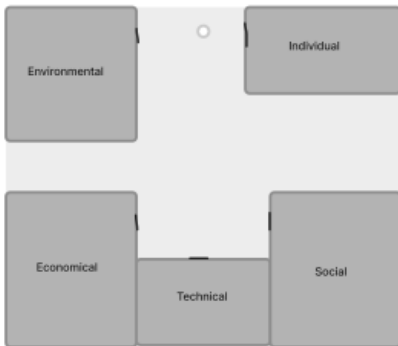
Play as two characters in different times, and work together to create a sustainable future for FuturiT and the world."



The players will start the game in the same office, but they will see different versions of it. One player will be in the office of the past, while the other will be in the office of the future.



The color scheme and setting in the past and the future is also different. The past will be more bright and vibrant, while the past will be dark and gloomy.



In the office, there are doors with numbers on them that leads to a room that deals with one of the dimensions of sustainability. In each room the player in the past is faced with a set of decisions to make, and they will need the help of the person in the future to find the more sustainable choices.



Both players have to choose a room to go into first, and it is important that they choose the same room to sync the game. To finish the room they will have to make a set of decisions.



For the player in the past, there will be some people in the room handing out tasks. They will have some type of decision they need input on, and will ask the player for help.



The tasks will be connected to the sustainability dimension of the room, and all of the possible decisions will have a certain impact. To make an informed decision, the players will have to search for clues and solve puzzles, which will give them more information.



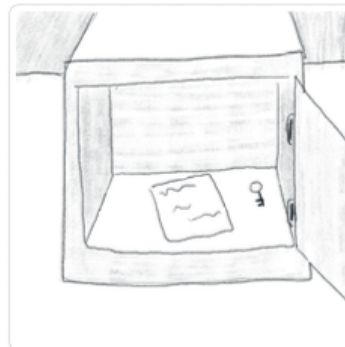
The players can work on different tasks at the same time for the same room, and will be able to find clues connected to different tasks. The players will therefore have to discuss which clues they think is connected to each task within a room.



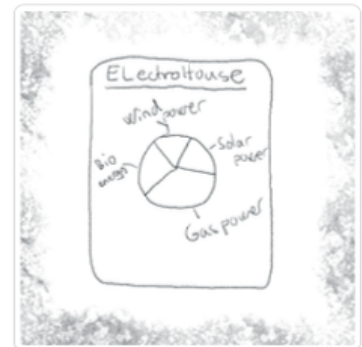
The players should be able to walk around, pick up things, have conversations with people in the office (Past), interact with different things to solve puzzles, like for instance clicking on buttons, turning a dial. They can also zoom in on paintings and pictures on the wall.



To find clues, the players search in their respective environments. Some clues are hidden, and might only be revealed by information that only lies in the past or in the future. For instance, the code to a safe in the future may only be found in the same room from the past.



When they solve puzzles they find new items that can solve new puzzles, or give information needed to solve a task



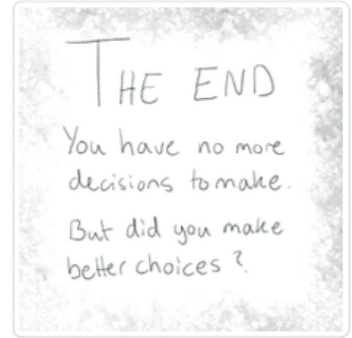
The clues can either be obscure or explicit in the way they inform the player.



When the players are ready to pick their choice, both the player in the past and the player in the future input this choice to sync the game, although in different ways. The choice they make will have an effect on both the past and the future, where the player in the past will see the immediate effects, and the player in the future sees the longterm effects.



While the player in the past makes the decision by talking to the task-giver, the player in the future has a time-travelling device which will ask for the decision for each task. The effects of the choice will then reveal themselves.



When all decisions have been made in all of the rooms, the players reach the end of the game.



They will then be provided with an overview of how they did in each room, and how sustainable their choices was.

Storyboard V2



The start screen of the game. Players can choose between loading a previously started game, starting a new game, going into the options menu, or quitting the game.



When the players click start new they are presented with the choice between the past or the future. One player have to pick the past, and the other must pick the future.



In the introduction scene of the game, the players are shown the outside of the office building for an IT company called FuturIT, on a bright summer day.



Inside, employees are busy working by their desks and chatting with their colleagues, and seemingly very happy and enthusiastic about their jobs. The company is very successful, and is the main provider of IT-solutions for the country.



The new CEO of the company, Thomas Tech, can be seen in the next shot, smiling widely and looking somewhat smug while watching his employees. He is very happy with his new position, and have great plans in mind for the future of the company.



The camera then zooms in on a person sat at one desk, that is looking somewhat worried at their computer screen.



A ticking noise can be heard in the background, and the shot changes to a clock that is going faster and faster until it stops.



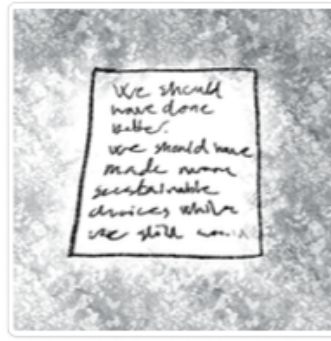
It is now 10 years later. The room is now more dark and gloomy, and the music is more somber.



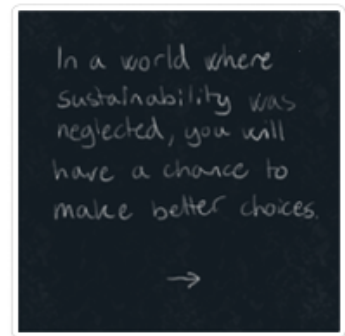
Outside the rain is pouring, and lightning strikes can be seen over a dark and dirty city, that is surrounded by thick fog and pollution. In the foreground, there is a wilted plant.



In the next scene, the desk that the worried worker once sat at is in focus, and there is a note on it with shaky letters.



The letter reads: "We should have done better. We should have made more sustainable choices while we still could."



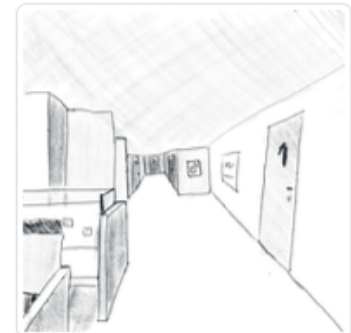
Then, the screen turns black, and there is a message that reads: "In a world where sustainability was neglected, you will have the chance to make better choices."



Play as two characters in different times, and work together to create a sustainable future for FuturiT and the world."



For the player in the past, the game starts with a meeting with Thomas Tech, the CEO. He wants the player to make rounds in the office to make sure that all of the teams are making sure that their projects are doing what it takes to make FuturiT more profitable.



The players will both play in the same office, but they will see different versions of it. One player will be in the office of the past, while the other player will be in the office of the future.



The color scheme and setting in the past and the future is also different. The past will be more bright and vibrant, while the future will be dark and gloomy.



In the office, there are rooms that belong to different teams, that are working on different projects for the company. In each room the player in the past is supposed to find the more profitable decisions, but with the help of the person in the future they can instead make the projects more sustainable.



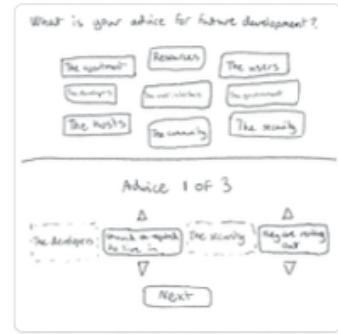
The players can choose which room they want to go into first, as the rooms are independent of each other. It is important that they choose the same room to sync the game.



When the players are ready to give their advice, both the player in the past and the player in the future have to input their choices to sync the game. When they press yes they cannot go back and search for clues, so they will have to be sure that they have everything they need.



The players will both see an advice screen where they create three sentences that will influence the project. The screen features different words that the players can choose from to use in their advice sentences. Between each word there are also a set of connecting sentences that the players can choose from, to finish the full sentence.



The players will therefore be able to make a many different sentences, which can result in different outcomes. If the players input a sentence that does not have an outcome (Nonsensical sentences), there will be feedback prompting them to change the sentence.



The input advice will influence the project, and will have an effect on both the past and the future, where the player in the past will see the immediate effects, and the player in the future sees the longterm, systemic effects.



The players will see what went well and changed for the better, and also see the parts that still have potential for improvement. There is no perfect ending, only different endings



For the player in the past, there will be some people in the room talking about the project and giving out information. The player in the future will see the same room, but without any people in it and with a more worn down and gloomy look to it.



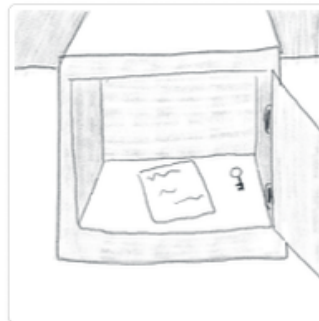
Players have to use both perspectives to piece together what might have gone wrong, and the idea is that everything that could go wrong did. They will have to collaborate to understand how to give advice that makes the team make a more sustainable solution.



The players should be able to walk around, pick up things, have conversations with people in the office (Past), interact with different things to solve puzzles, like for instance clicking on buttons, turning a dial. They can also zoom in on paintings and pictures on the wall.



To find clues, the players search in their respective environments. Some clues are hidden, and might only be revealed by information that only lies in the past or in the future. For instance, the code to a safe in the future may only be found in the same room from the past.



When they solve puzzles they find new items that can solve new puzzles, or give information needed to solve a task



The clues can either be obscure or explicit in the way they inform the players. It is up to the players to interpret the hints and clues, and then finally decide what advice they want to give to the team.

Appendix E

Group Evaluation Questionnaire

Spørreskjema for spillevaluering

Bakgrunn

Litt om din erfaring

Har du i løpet av dine studieår på universitetet hatt undervisning der bærekraft har vært et tema?

- Ja
- Nei
- Usikker

Dersom du svarte ja på forrige spørsmål, ble bærekraft undervist i sammenheng med IT?

- Ja
- Nei
- Usikker

Har du erfaring med å spille dataspill?

- Ja
- Nei
- Usikker

Hvor ofte spiller du i fritiden?

- Aldri
- Svært sjelden
- Sjelden
- Ofte
- Svært ofte
- Alltid

Har du hatt fag på universitetet der spill ble brukt som et læringsverktøy?

- Ja
- Nei
- Usikker

Synes du spill kan være nyttig som et læringsverktøy på universitetet?

- Ja
- Nei
- Usikker

Påstander

Nå kommer noen påstander som du skal ta stilling til. Svar så ærlig som mulig ut i fra ditt ståsted.

Jeg ønsker å lære mer om bærekraft i sammenheng med IT

- Helt uenig

Uenig
Nøytral
Enig
Helt enig

Bærekraft har vært en viktig faktor i mine tidligere IT-prosjekter

Helt uenig
Uenig
Nøytral
Enig
Helt enig

IT kan løse bærekraftsutfordringene vi står ovenfor i dag

Helt uenig
Uenig
Nøytral
Enig
Helt enig

IT er en del av bærekraftsproblemet

Helt uenig
Uenig
Nøytral
Enig
Helt enig

Bærekraft er komplekst, og det er ikke mulig å finne en enkelt løsning på utfordringene.

Helt uenig
Uenig
Nøytral
Enig
Helt enig

Bærekraft må tas hensyn til selv om IT-systemets primærfokus ikke er bærekraft

Utdyping: I designfasen av et nytt IT-system må bærekraft vurderes selv om IT-systemet i utgangspunktet ikke har som formål å bidra til bærekraft.

Helt uenig
Uenig
Nøytral
Enig
Helt enig

Jeg har et ansvar for langtidseffektene av systemene jeg er med på å bygge

Helt uenig

Uenig

Nøytral

Enig

Helt enig

Er det noe du ønsker å legge til?

Appendix F

Group Evaluation Questionnaire responses

Spørreskjema for spillevaluering

Oppdatert: 27. juni 2023 kl. 13:38

Bakgrunn

Litt om din erfaring

Har du i løpet av dine studieår på universitetet hatt undervisning der bærekraft har vært et tema?

Antall svar: 6

Svar	Antall	% av svar	
Usikker	0	0%	0%
Nei	3	50%	50%
Ja	3	50%	50%

Dersom du svarte ja på forrige spørsmål, ble bærekraft undervist i sammenheng med IT?

Antall svar: 4

Svar	Antall	% av svar	
Usikker	0	0%	0%
Nei	1	25%	25%
Ja	3	75%	75%

Har du erfaring med å spille dataspill?

Antall svar: 6

Svar	Antall	% av svar	
Usikker	0	0%	0%
Nei	0	0%	0%
Ja	6	100%	100%

Hvor ofte spiller du i fritiden?

Antall svar: 6

Svar	Antall	% av svar	
Alltid	0	0%	0%
Svært ofte	1	16.7%	16.7%
Ofte	2	33.3%	33.3%
Sjelden	2	33.3%	33.3%
Svært sjelden	1	16.7%	16.7%
Aldri	0	0%	0%

Har du hatt fag på universitetet der spill ble brukt som et læringsverktøy?

Antall svar: 6

Svar	Antall	% av svar	
Usikker	0	0%	0%
Nei	1	16.7%	16.7%
Ja	5	83.3%	83.3%

Synes du spill kan være nyttig som et læringsverktøy på universitetet?

Antall svar: 6



Svar	Antall	% av svar	
Usikker	1	16.7%	16.7%
Nei	0	0%	0%
Ja	5	83.3%	83.3%

Påstander

Nå kommer noen påstander som du skal ta stilling til. Svar så ærlig som mulig ut i fra ditt ståsted.



Jeg ønsker å lære mer om bærekraft i sammenheng med IT

Antall svar: 6

Svar	Antall	% av svar	
Helt enig	5	83.3%	 83.3%
Enig	1	16.7%	 16.7%
Nøytral	0	0%	0%
Uenig	0	0%	0%
Helt uenig	0	0%	0%



Bærekraft har vært en viktig faktor i mine tidligere IT-prosjekter

Antall svar: 6

Svar	Antall	% av svar	
Helt enig	0	0%	0%
Enig	0	0%	0%
Nøytral	0	0%	0%
Uenig	4	66.7%	 66.7%
Helt uenig	2	33.3%	 33.3%






IT kan løse bærekraftsutfordringene vi står ovenfor i dag

Antall svar: 6

Svar	Antall	% av svar	
Helt enig	0	0%	0%
Enig	4	66.7%	 66.7%
Nøytral	2	33.3%	 33.3%
Uenig	0	0%	0%
Helt uenig	0	0%	0%






IT er en del av bærekraftsproblemet

Antall svar: 6

Svar	Antall	% av svar	
Helt enig	3	50%	 50%
Enig	3	50%	 50%
Nøytral	0	0%	 0%
Uenig	0	0%	 0%
Helt uenig	0	0%	 0%






Bærekraft er komplekst, og det er ikke mulig å finne en enkelt løsning på utfordringene.

Antall svar: 6

Svar	Antall	% av svar	
Helt enig	4	66.7%	 66.7%
Enig	2	33.3%	 33.3%
Nøytral	0	0%	 0%
Uenig	0	0%	 0%
Helt uenig	0	0%	 0%

Bærekraft må tas hensyn til selv om IT-systemets primærfokus ikke er bærekraft

Antall svar: 6

Svar	Antall	% av svar	
Helt enig	4	66.7%	 66.7%
Enig	2	33.3%	 33.3%
Nøytral	0	0%	 0%
Uenig	0	0%	 0%
Helt uenig	0	0%	 0%

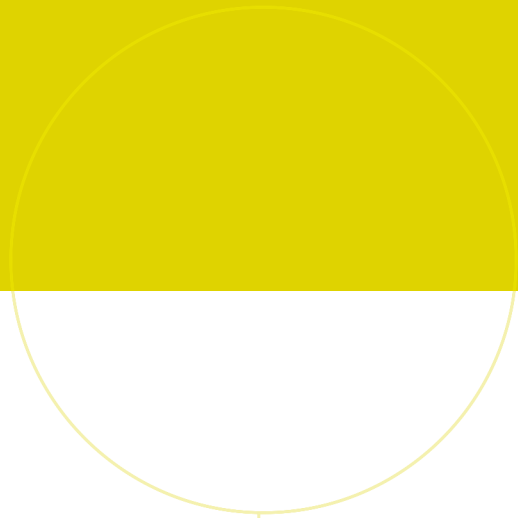
Jeg har et ansvar for langtidseffektene av systemene jeg er med på å bygge

Antall svar: 6

Svar	Antall	% av svar	
Helt enig	4	66.7%	66.7%
Enig	2	33.3%	33.3%
Nøytral	0	0%	0%
Uenig	0	0%	0%
Helt uenig	0	0%	0%

Er det noe du ønsker å legge til?

Dette spørsmålet har ingen svar



 **NTNU**

Norwegian University of
Science and Technology