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Digital Descent: A simulation-based serious game for teaching Agile Software Development

Master's thesis in Informatics

Supervisor: Monica Divitini

Co-supervisor: Dag Frode Solberg

June 2023

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
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Abstract

The Agile methodology has gained significant popularity in recent years, especially among software development teams. However, the increasing adoption of Agile methodologies has highlighted the need for effective and efficient approaches to learning these methodologies. The widespread use of Agile practices has also revealed several challenges associated with adoption and learning, as it requires comprehensive organizational changes to achieve success. As a result, many studies have explored the use of serious games, known for their engaging and enjoyable nature, as an effective pedagogical approach in various educational contexts.

This research explores the development of a game for teaching Agile methodology concepts. It builds upon the findings of a previous specialization project conducted by the authors, which examined the challenges of adopting Agile Software Development and identified high-level requirements for creating an effective game. The specialization project revealed that simulation-based games were particularly successful in teaching Agile Software Development.

In this thesis, the initial findings from the specialization project are integrated with a comprehensive literature review, identifying additional game elements that promote communication and collaboration, to design and develop a serious game aimed at teaching Agile Software Development concepts to students in their final years and newly graduates, called Digital Descent. The development of Digital Descent follows an iterative design process, involving the active participation of students, experts in agile methodologies, and game design through three prototype evaluations. Through the multiple rounds of evaluation and feedback, the game prototype demonstrated significant potential, indicating its viability as an effective educational tool for teaching Agile methodology concepts. The game design of Digital Descent and this thesis represents a solid basis for future work in the field of simulation-based serious games for learning Agile Software Development concepts.

The game Digital Descent is available at <https://shirajuki.github.io/digital-descent>.

Sammendrag

Smidig metodikk har blitt svært populær de siste årene, særlig blant programvareutviklingsteam. Økende bruk av smidig metodikk har satt søkelyset på behovet for å utvikle effektive metoder for å lære seg denne metodikken. Den utstrakte bruken av smidige metoder har også avdekket flere utfordringer knyttet til læring og bruken av smidig metodikk, ettersom det krever omfattende organisatoriske endringer for å oppnå suksess. Som et resultat av dette har mange studier utforsket bruken av seriøse spill, som er kjent for å være engasjerende og underholdende, og som kan være en effektiv pedagogisk tilnærming i ulike utdannings-sammenhenger.

Denne avhandlingen utforsker utviklingen av et spill for å lære bort konsepter innen smidig metodikk. Den bygger på funnene fra et tidligere fordypningsprosjekt, der utfordringer ved bruken av smidige metoder innen programvareutvikling ble undersøkt. Fordypningsprosjektet resulterte i overordnede spesifikasjonskrav for å lage et effektivt læringsspill. Fordypningsprosjektet avdekket også at simuleringsbaserte spill var spesielt vellykket som et undervisningsverktøy for å lære studenter smidig utvikling.

Resultatene fra fordypningsprosjektet ble brukt sammen med funnene fra en litteraturgjennomgang som identifiserte spillelementer som fremmet kommunikasjon og samarbeid. Dette ble deretter brukt for å designe og utvikle et seriøst spill kalt Digital Descent. Dette spillet har som mål å lære bort konsepter innen smidig utvikling til studenter på siste studieår og nyutdannede. Utviklingen av spillet følger en iterativ designprosess som involverte flere evalueringsrunder med studenter, eksperter på smidige metoder og spilldesign. Gjennom tilbakemeldingene fra evalueringene har spillprototypen vist seg å ha et betydelig potensial til å være et effektivt pedagogisk verktøy for å lære bort konsepter innenfor smidig metodikk. Spilldesignet i Digital Descent og denne avhandlingen representerer et solid grunnlag for fremtidig arbeid innen simuleringsbaserte seriøse spill for læring av konsepter innen smidig programvareutvikling.

Spillet Digital Descent er tilgjengelig på <https://shirajuki.github.io/digital-descent>.

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Chapter 1

Introduction

1.1 Motivation

In the last few years, Agile has proven to be the most popular methodology, as more teams are adopting it each year (ai, 2022). *Agile* is a project management methodology that emphasizes collaboration in self-organizing teams and allows for incremental development through iterations. The incremental iterations enable faster feedback and the possibility of making changes. Traditionally, project methodologies followed a sequential flow of steps and phases. This approach suited situations where the requirements were well understood, and there was a clear picture and understanding among stakeholders on the final product, making changes to the projects less likely. Changes were avoided as they were riskier the further into the project they were made. Today, changes occur fast and frequently, as changes are inherent to the nature of software projects. Therefore, the IT industry views Agile as a more suitable project management methodology for software development (Kropp & Meier, 2013a). As a consequence, a strong understanding of Agile is essential to ensure the success of projects.

The widespread usage of Agile has highlighted the gap between the skills required by the IT industry and the skills acquired by students and professionals with no Agile knowledge (Kropp & Meier, 2013b), (Lundqvist et al., 2019). Therefore, the IT industry experiences challenges in both Agile adoption and learning. These challenges of adoption and learning are intertwined. Poor training and improper use of the Agile methodology are at the root of most problems. The challenges identified in Agile learning are human-related, including resistance to change, lack of effective communication, and a lack of experience and knowledge of Agile methods and practices (Stray et al., 2020a) (Le & Ngo, 2022). Students learn Agile through theories and concepts but gain little practical experience using them. The few universities that provide practical experience through software projects often do so poorly and in an overwhelming manner, which influences the motivation and learning outcomes of the students.

Educational games have been used in various fields to make learning more enjoyable and motivating (Hawlitschek & Joeckel, 2017). There are currently a

number of games that can teach Agile, but there is an overhead to using them. They don't fit into different learning contexts and are time-consuming to set up. This thesis aims to develop a serious game to teach students and professionals the Agile methodology and to ensure it fits into various learning contexts.

1.2 Context

This research is conducted in the context of a master's thesis for the Department of Computer Science at the Norwegian University of Science and Technology (NTNU). The research in this thesis builds upon the specialization project (Le & Ngo, 2022) from the same authors, which focused on examining how serious games can be designed to effectively introduce Agile methodology concepts. While the specialization project investigated existing literature and serious games for teaching Agile Software Development, this thesis presents the research, development, and prototyping of a serious game for teaching the concepts in Agile Software Development. This project is supervised by Professor Monica Divitini and co-supervised by Dag Frode Solberg. Both supervisors have provided thorough guidance to the authors in all parts and aspects of the project.

1.3 Research Questions

Serious games, known for their fun and engaging nature, have been widely adopted in various educational contexts as an effective pedagogical approach. Examples of such research in the field of Agile Software development include games such as Minetest (Steghofer, 2022) and Scrumify (Ammons, 2017a), which focus on teaching the Scrum methodology of Agile Software Development. The specialization project (Le & Ngo, 2022) identified several of these existing serious games in the context of Agile Software Development and laid the groundwork for a new serious game for teaching Agile methodology concepts. The authors believe that by combining various motivating game elements with the well-known success of simulation-based games, they can create a new and entertaining way of teaching Agile methodology concepts. As such, the main research question of the study is:

RQ1: How can a simulation-based serious game be made to teach Agile methodology concepts?

Our earlier work from the specialization project (Le & Ngo, 2022) revealed that the most common obstacles to learning and adopting Agile were time estimation, communication, and collaboration. Identifying strategies and game elements for overcoming these obstacles and challenges is therefore critical for a game to be effective in teaching Agile methodology concepts:

RQ1.1: How can simulation-based games be designed to educate players on the educational topic of agile software development, as well as the significance of communication and collaboration?

Additionally, our earlier work in the specialization project (Le & Ngo, 2022) found that one of the most common limitations of existing games was ease of access, as most games are designed for a specific setting and audience, often physically present and for students in a specific university. This is a problem because existing games do not work well in a distributed setting, which has recently become increasingly common for many developers. Facilitating the ability to learn and apply Agile in a distributed setting could overcome this limitation and other limitations presented in the specialization project (Le & Ngo, 2022). To address the limits of availability and ease of access, the game should be easy to set up and play:

RQ1.2: How can the game be designed so that it is available and easy to access to a wide audience while still complex enough to illustrate the real-world environment of Agile Software Development?

Finally, research from the specialization project indicates that gamification and game elements such as cooperation and playfulness motivate the players. The literature also states that for many, motivation and engagement are closely connected to effective learning. Knowledge will often come as a natural side-effect of being interested in a topic. The game should be created in such a way that it motivates players while also teaching them about the issues related to Agile learning outlined in the specialization project (Le & Ngo, 2022):

RQ1.3: Can we overcome the challenges associated with Agile learning by creating a game for Agile Software Development that incorporates motivating game elements?

1.4 Research Methods

To answer the main research question **RQ1**, the Design Science Research methodology (DSR) of (Hevner et al., 2010) was employed. The goal of DSR is to enhance human knowledge by creating new and innovative artifacts to solve problems and improve the performance of information systems.

The initial stage of the research, known as the Relevance Cycle, identifies a problem or opportunity within the context that the study aims to address. This cycle also defines the acceptance criteria for evaluating the research outcomes. Following this, the Rigor Cycle, serving as the second phase of the process, provides existing knowledge to the research to ensure its innovation. The third and crucial cycle, the Design Cycle, involves the creation of design artifacts, which are then iteratively compared against the project's requirements.

Since this thesis builds on a specialization project that explored how existing serious games have been used to learn Agile Software Development (Le & Ngo, 2022), the challenges relating to what individuals face when practicing Agile was also explored. These explorations revolved primarily around the Relevance and

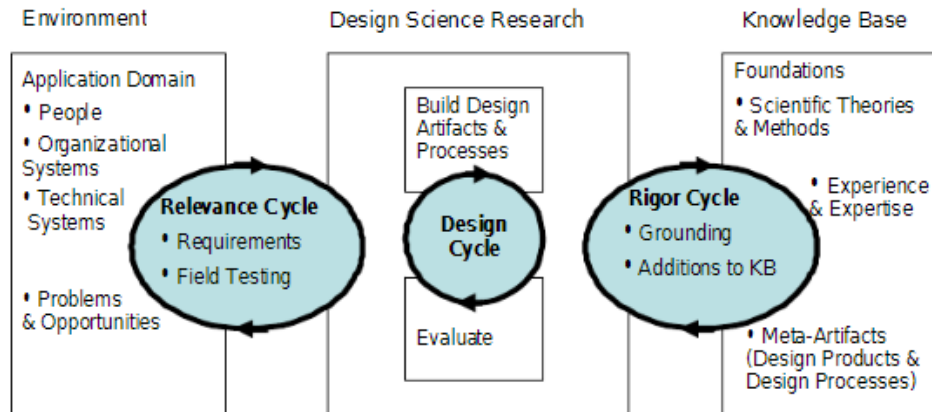


Figure 1.1: Design Science Research Cycles

Rigor Cycles. This initial research identified essential specifications and criteria for a serious game. It also incorporated relevant literature and theories into the knowledge base, highlighting the role of serious games and challenges related to Agile methodology.

The foundations laid in the specialization project have now led to a transition in the current phase of research, where the design of a serious game artifact is the goal. During this thesis, several data collection activities will be conducted to answer the research questions. Chapter 3 is devoted to providing a better understanding of game design and the elements used in games, presenting the related works. The design process is an iterative procedure, with several participating groups involved in evaluating the game. Firstly, the three generated game concepts will be proposed and evaluated in chapter 4 as the first cycle. The second cycle will be an evaluation of the usability of the first version of the prototype in chapter 7. The next cycle in chapter 8 will involve an expert evaluation with Agile experts and game design experts. The last cycle done during this thesis is the final evaluation, where the prototype will be evaluated with the target group which is presented in chapter 9. The evaluations will consist of observations on the gameplay testings, focus groups and interviews.

1.5 Results

This thesis presents several contributions to the field of simulation-based serious games for teaching concepts in Agile Software Development in a variety of ways, including a literature review, a game concept and design, a benchmark on popular javascript-based rendering and game engines by the time of writing this thesis, and, finally, the prototype of the serious game Digital Descent. The results are mainly acquired through a review of related works as well as evaluations of the game concept and prototype.

The literature review of the state of the art presents previous efforts on simulation-based serious games to gain insight into the approach and methods of creating an effective game for teaching Agile methodology concepts. The result is a classification of different motivational and learning game elements that are found to be effective in a serious game. Furthermore, more insight on serious games specifically designed for Agile Software Development are also explored.

Additionally, by combining the findings from the specialization project and related works, three game concepts were proposed. In order to choose one concept, different game elements in relation to motivation and learning outcome of the game were extracted and examined. The end result is a mapping of general simulation-based serious game elements and game mechanics that is found to be effective. These findings, as well as the result of previous research, resulted in the game design for the serious game Digital Descent.

The specialization project laid the groundwork for four learning objectives, which were generated during the process of designing the game concept. The game prototype was specifically created with the aim of addressing these learning objectives, targeting the challenges and limitations identified in the specialization project by focusing on enhancing player engagement and fostering collaborative and communication skills. The game is readily accessible online at <https://shirajuki.github.io/digital-descent>. The final contribution of this research is the results from the evaluations of Digital Descent. The results suggests that simulation-based games have the potential to teach Agile Software Development concepts in an engaging manner.

1.6 Outline

This thesis consists ten chapters in total. Chapter 2 provides an elaborate problem definition and presents findings from the specialization project (Le & Ngo, 2022). In chapter 3, a literature review on game design and simulation-based games is presented and discussed. Additionally, chapter 4 describes three different game concepts derived from the proposed high-level requirements outlined in the specialization project, along with the results of the related works. It also explains the process of selecting one concept for further development, implementation, and evaluation. Chapter 5 presents the initial state of the game concept and design, while the technical aspects of the game, including the technologies used, are described in chapter 6. The different iterative design and evaluation processes of the game development, along with discussions of the feedback received and the corresponding changes made, are described in chapter 7, chapter 8 and chapter 9. Finally, a comprehensive conclusion of the study is presented in chapter 10.

Chapter 2

Problem Definition

This chapter starts with a summary of the specialization project and introduces the concept of Agile software development. The subsequent subsections will provide a more detailed presentation of the findings from the specialization project.

2.1 Summary of the specialization project

The findings from the specialization project are used in this master's project (Le & Ngo, 2022). The purpose of the specialization project was to investigate the challenges associated with adopting Agile software development and to devise a serious game for learning Agile software development in order to mitigate these challenges. As a summary of the specialization project, a review of the literature was conducted to identify existing Agile learning games and evaluate how they compared to one another. The findings revealed that various Agile learning games had a limited scope and focused primarily on the Scrum methodology. The games did not sufficiently emphasize Agile values and concepts, which are essential for creating a strong Agile mindset. Many of the games required participants to be physically present in order to play, making it unsuitable for a distributed setting. Additional findings concerned the games being designed for a specific context, primarily university students. Because of this constraint, they present difficulties to set up and use for learners from different backgrounds or with varying levels of experience outside of the same research context. Finally, the research on Agile adoption emphasizes the significance of cultivating the Agile mindset through the learning and practice of Agile values and principles. A deep understanding and awareness of the Agile mindset can eventually result in better Agile adoption since challenges related to communication, organizational culture, and resistance to change can be avoided.

2.2 The concept of Agile Software Development

Agile software development (ASD) is a collaborative approach to software development in which requirements and solutions evolve through the efforts of self-organizing and cross-functional teams (Moniruzzaman & Hossain, 2013). It refers to a set of software development methodologies that is based on an iterative approach. Agile software development focuses on flexibility, team collaboration and continuous improvement to deliver quality products. Furthermore, it involves breaking down the project into small and incremental stages. Each stage incorporates frequent feedback and iteration from the development team and the customer. The development team works closely with the customer to shape and prioritize the product requirements. In the end of each iteration, the software product is reviewed and refined in the next subsequent iteration. Some of the practices of Agile software development include daily stand-up meetings, user stories, refactoring, iteration planning and retrospective. These practices are often called Agile methods and are picked and combined after what the team needs and prefers.

Cockburn and Highsmith define Agile Software Development as a conceptualization of values and practices rather than a specific process or set of rules (Highsmith & Cockburn, 2001). When several Agile methods are used together, the values outlined in the Agile Manifesto are said to be shared. The subsequent section will present the Agile manifesto which is the core of Agile Software Development.

2.2.1 Agile manifesto

The Agile manifesto is the fundamentals of what Agile software development is today. In 2011, a group of 17 software developers gathered and discussed the future of software development. The result of this gathering is the Agile Manifesto which consists of four core values and twelve principles that guide the Agile software development (Alliance, 2001). The four Agile core values are the following:

1. **Individuals and interactions over processes and tools**

The focus is on the people. People are the ones who, in the end, are responsible for creating and using the software. Even if you have the best tools and technologies, the quality of the software will suffer if there is insufficient communication and interaction among the people.

2. **Working software over comprehensive documentation**

Documentation, such as technical specifications and requirements, consumes a significant amount of time in traditional project management. Agile simplifies this by suggesting the use of user stories to simplify the extensive documentation. Documentation should aid developers in understanding the software. The emphasis should be on working software rather than documentation.

3. **Customer collaboration over contract negotiation**

Instead of focusing on negotiations, Agile prioritizes close collaboration with the customer. It is the responsibility of both the customer and the project

team to collaborate on the delivery details. In order to ensure that the project is moving in the right direction and that it is living up to the requirements laid out by the customer, the customer needs to be involved in every stage of the development process. Collaboration with customers also offers periodically useful feedback and insights into a different domain, both of which can contribute to the improvement of the product.

4. Responding to change over following a plan

Changes are unavoidable and necessary in the development process to produce high-quality software. On the other hand, changes are more expensive the later they are made in the development process. As a result, agile works with short iterations that allow changes to be made quickly based on feedback obtained at the end of each iteration.

Following the four agile core values, the twelve principles of the Agile Manifesto to be followed by practitioners are described in Table 2.1.

2.2.2 Agile software development methods

Agile methodology frameworks were developed to categorize different Agile methods. These frameworks play a significant role in software development, providing structure and guidance. Various Agile methodology frameworks are commonly employed in software development, each with its own emphasis and approach. Some methods, like Extreme Programming (XP), place importance on specific practices to achieve agility. Others, such as Scrum and Kanban, focus on optimizing the flow of work. Here is an overview of some of the most popular frameworks:

Scrum

An iterative project management model that allows teams to focus on delivering the most value in the least amount of time (Dybå & Dingsøy, 2008). A self-organizing team creates software in increments called sprints, beginning with a planning phase and ending with a review. In a Scrum process, features to be implemented in the system are registered in a list called the backlog, and the product owner, who is part of the stakeholders, decides which backlog items will be developed in the next sprint. Team members coordinate their work in daily stand-up meetings, with one member serving as the scrum master in charge of resolving issues that prevent the team from working effectively. Scrum is a methodology that continuously uses team collaboration to improve the development process through feedback loops.

Extreme programming (XP)

An iterative methodology that focuses on improving the quality of software and reducing development time (Dybå & Dingsøy, 2008). XP emphasizes best practices for development and consists of a set of engineering practices that focus on

Principle	Description
1	Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2	Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3	Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4	Business people and developers must work together daily throughout the project.
5	Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6	The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7	Working software is the primary measure of progress.
8	Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9	Continuous attention to technical excellence and good design enhances agility.
10	Simplicity—the art of maximizing the amount of work not done—is essential.
11	The best architectures, requirements, and designs emerge from self-organizing teams.
12	At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

Table 2.1: The 12 Principles of the Agile Manifesto

collaboration between the customer, developers, and other stakeholders throughout the development process. XP encourages practices such as automated testing and refactoring, pair programming, continuous integration, collective ownership, and frequent customer feedback and collaboration to ensure that the software meets the customer's needs through small releases while maintaining high maintainability. XP is often used in combination with other agile methodologies such as Scrum or Kanban.

Kanban

An iterative project management framework that focuses on improving the flow of work by graphically visualizing an entire project using a board (Kniberg & Skarin, 2010). Features or tasks to be implemented in the increment are registered as

Work in Progress (WIP) on a whiteboard (either physical or digital) called Kanban boards. Team members use the board to monitor progress, manage tasks, and visualize the workflow, which is done through a system in which tasks are moved from one column to another, typically from left to right. The core principle of Kanban is that the tasks that is WIP should be limited, which is accomplished through the use of the Kanban board.

Scrumban

An iterative project management method based on a set of elements borrowed from Scrum and Kanban (Ladas, 2009). The hybrid agile methodology involves applying Kanban principles of WIP limitation and workflow visualization, as well as the flexible structure and processes from the Scrum methodology.

2.3 Challenges of Agile

2.3.1 Adopting Agile

Agile methodologies have gained significant popularity in the IT industry for software development projects in recent years. According to the latest State of Agile Report (ai, 2022), 94% of respondents reported that their organizations practice Agile, with many citing speed and flexibility as the primary reasons for adoption. Furthermore, the report indicates that respondents recognize the value of expanding Agile adoption as a means of achieving critical business outcomes, and they anticipate this trend to continue. Consequently, having a good understanding and knowledge of Agile principles and practices has become important for future project managers and developers.

However, the wide usage of Agile practices also come with a number of challenges in adopting the Agile methodology. Implementing Agile in an organization is significantly more difficult than it initially appears, as it involves a change of existing processes and in all aspects of the organization for a successful adoption. According to the State of Agile Report, the following are the most significant Agile adoption barriers:

- Inconsistencies in processes and practices - 46%
- Cultural clashes - 43%
- General organizational resistance to change - 42%
- Lack of skills and experience - 42%
- Absence of leadership participation - 41%
- Inadequate management support and sponsorship - 40%
- Insufficient training and education - 35%

Similarly, Sadaquat et al. (Ruk, 2019) conducted a survey of 50 people from various organizations, and the results mirrored those of the State of Agile Report. They identified cultural issues, lack of requirements, software project management, and team communication as the most challenging aspects of Agile adoption.

2.3.2 Perceived challenges in Agile adoption

In order to further investigate the challenges in Agile adoption and learning, interviews were partially conducted in the specialization project (Le & Ngo, 2022). The interview's purpose was to understand better the difficulties in adopting Agile and the learning challenges of Agile. The findings from the interviews highlighted the importance of having a clear understanding of the Agile principles and practices to choose the appropriate tool for the task rather than the other way around. The interview also addressed the difficulties associated with scaling Agile for large organizations. Although close communication and collaboration with stakeholders is one of the core values of Agile, the size of the teams and the project scope made it difficult for team members and customers to communicate and collaborate effectively. Implementing Agile in practice, namely, communication and collaboration, is not as straightforward as it may appear. Due to time constraints, just the pilot interview was conducted, hence the findings are limited. Nevertheless, the pilot interview provided valuable insights into the fundamental problems that certain organizations experience when adopting Agile.

2.3.3 Challenges in learning Agile

A literature review was conducted as part of the specialization project (Le & Ngo, 2022) to gain a general understanding of the issues and challenges in Agile learning and how it has been researched in the past.

Stray et al. (Stray et al., 2020b) discovered that most Agile learning challenges are human-related, such as resistance to change, ineffective communication, and a lack of experience and understanding of Agile practices and techniques. Additionally, customer participation and collaboration, which can be seen as a core value of Agile according to the Agile Manifesto, were also considered difficult in practice. Similarly, Milašinović and Fertalj (Milašinovic & Fertalj, 2018) identified human factors as the primary hindrance and barrier to adopting Agile values in organizations, mentioning similar challenges such as lack of knowledge, resistance to change, and lack of collaboration. A study by Shameem et al. (Shameem et al., 2018) identified most of the same challenges, emphasizing management-related challenges as the most important ones that must be addressed. These included ineffective communication and knowledge sharing.

Numerous studies, including the research conducted by Masood et al. on the challenges of implementing Agile learning in the university context (Masood et al., 2018), identified several key issues that require attention as well. These challenges were variations in student motivation and goals within courses, limited availability and support from customers due to busy schedules, difficulties in establishing a coordinated time for team collaboration, and a lack of guidance from experienced Agile coaches or Scrum Masters. Furthermore, the study reported other challenges, such as students being required to balance multiple courses alongside personal and professional commitments. To adapt Agile practices to the university context, students undertake daily stand-ups with reduced frequency and combine

sprint meetings.

Similarly, Milašinović and Fertalj assert that the university context differs from real-world settings in certain respects (Milašinović & Fertalj, 2018). Students, for instance, may encounter distractions from other activities and classes, and the absence of a dedicated working space necessitated extra effort for meetings and collaboration. Consequently, various Agile methods and practices are typically tailored to the university context to ensure their suitability for learning. It is important to note that this adaptation presents both benefits and drawbacks compared to real-world settings.

Overall, these studies consistently reveal that most challenges in Agile adoption stem from human factors. Ineffective communication and collaboration, resistance to change, and varying levels of motivation depending on the context of Agile implementation are recurring challenges.

The emphasis on people, including aspects such as roles, interactions, and abilities, is viewed more vital than agile methods and tools (Cockburn & Highsmith, 2001). Therefore, people's roles, responsibilities, and behaviours can be seen as the primary sources of many challenges. Given the importance of these factors, it is essential that all the stakeholders understand the Agile principles and practices, as well as being capable of effective communication and collaboration.

2.3.4 Method tailoring

Additionally, the constant strive of new and efficient development methods that can be applied across various software development projects presents a challenge in Agile adoption. In reality, software projects are inherently unique, and there is no such thing as a one-size-fits-all method or framework (Pikkarainen, 2005a). Successful software development projects rarely adopt the Agile methods in a strict fashion. Rather they are customized to align with specific contextual characteristics. Consequently, determining which Agile method to use for a project can be tricky at times, as the decision typically relies on experiential insights into which methods and practices are likely to work well. The existing literature has used various terms interchangeably to describe the process of tailoring methods, such as method tailoring, method adaptation, and process tailoring (Cesare, 2008) (Ayed, 2014) (Akbar, 2019). Method tailoring is defined as:

“a technique to customize or adapt the software development process according to the requirements of the software project or company by removing unnecessary and unwanted practices and activities from the process.” (Akbar, 2019)

Developing processes and methods from scratch is risky and involves high overhead (Xu, 2008). As a result, teams often tailor existing processes and methods to suit their company and project needs. However, studies show that method tailoring is time-consuming and challenging (Ocampo, 2005). This is primarily due to the requirement of a thorough understanding of the company's operations,

rules, limitations, standards, and procedures. Inexperienced individuals often focus too heavily on understanding specific tools, methods, and frameworks, neglecting the broader and more critical aspects such as human factors. Additionally, it is necessary to understand the unique requirements of the different projects before doing the method tailoring process. Poorly executed method tailoring has many consequences which includes increased project costs and development time, ultimately resulting in wasted time and resources. Since the project budget, development time, and software quality depend on the implementation of software processes, it is important to avoid such inefficiencies.

Finally, organizations require procedures and methods to support the systematic selection and deployment of new agile practices (Pikkarainen, 2005b). Unfortunately, agile methods do not provide a clear default guideline on their implementation. As a result, businesses need some assistance and guidance in breaking through this barrier.

2.4 Limitations in existing Serious Games

A literature review was also conducted in the specialization project to gain a thorough understanding of the topic of game-based learning and gamification in the context of teaching Agile Software Development, and how it has previously been researched.

Looking at existing serious games discovered through the literature review, it is clear that there have been a substantial amount of research on the concept of using serious games to teach Agile Software Development. However, the majority of the studies have a limited scope and do not provide an in-depth understanding of the Agile Development process as a whole, instead focusing on certain Agile methods and frameworks, such as the Scrum methodology. Furthermore, some studies describe the usage of games that were not explicitly designed for teaching Agile Software Development. Instead, these research studies have examined the effectiveness of existing entertainment games and explored how they could be utilized to teach the Agile principles of the Scrum methodology.

In addition, existing games are similarly limited in their design in that they require all players to be physically present, making them difficult to use in a distributed environment. These games are also either designed to be played individually or have a limited communication flow, making collaboration and Agile learning challenging. As stated in the first of the four Agile Manifesto values, an Agile project should place a higher emphasis on improving communication and interaction among the stakeholders. Furthermore, the results from the State of Agile report indicates that the majority of the respondents practicing Agile in their daily work intend to continue working in either fully remote mode (25%) or hybrid (56%) (ai, 2022). As a result of the COVID-19 pandemic, it is clear that the ability to learn and implement Agile in a distributed environment is crucial.

Finally, many existing research studies have built games for a specific audience and with certain requirements, generally university students at a specific univer-

sity. This makes the games challenging to set up and use for a target group with diverse backgrounds or varying levels of experience outside of the same study area. In addition, some games use external technologies and digital platforms alongside the games as features for communicating and organizing. There are some downsides to these, such as being vulnerable to external factors like system downtime and technical issues, which may diminish the immersive qualities of the games. To remedy this, games should be made more available to a wider audience, have more user-friendly interfaces and tutorials, and provide players with more options for personalization. Incorporating the features of external technology inside the game to improve its usability is also considered a good idea.

2.5 High-level requirements for a Game that teaches Agile Software Development

The main contribution of the specialization project was a list of high-level requirements to create a game for this research project. The requirements are based on the motivational factors and teaching approaches identified in the literature review. The requirements are displayed in Table 2.2. The requirements are annotated with the prefix 'HR', signifying 'High-level Requirement', and categorized into Agile value, game element or both. These high-level requirements will be examined in greater detail in the coming chapters and be used to define the game's learning objectives.

Req.	Description	Category
HR01	The game should provide actual project development experience, enough to illustrate real-world scenarios through simulation	Agile value
HR02	The game should provide players with decision-making skills through various scenarios and choices-driven elements. In addition, adequate consequences and feedback should be provided regarding their decisions	Agile value/Game element
HR03	The game should involve and emphasize Agile methodology concepts such as time estimation, communication, and collaboration	Agile value
HR04	The game should include a customer role, focusing on story-driven communication between the player and the customer	Agile value
HR05	The game should allow players to communicate effectively, ensuring collaboration and fluency in communication. This could include real-time communication through chats or voice calls	Agile value/Game element
HR06	The game should allow an instructor to monitor and inspect the player's activity and progress	Game element
HR07	The game should include motivational elements such as rewards, player customization, and levels	Game element
HR08	The game should be simple and easy to learn and play	Game element
HR09	The game should be accessible to a large audience regardless of different levels of experience or background, easy to set up for players and instructors	Game element

Table 2.2: High-level requirements

Chapter 3

Related works

This chapter provides an overview of relevant works and investigates various game mechanics used in successful serious games. It presents a summary of existing simulation games in Agile software development from the specialization project (Le & Ngo, 2022), along with a variety of literature on successful case studies involving simulation games. Additionally, it goes into the role of different game mechanics in simulation games, investigating how these can enhance player engagement and learning outcomes.

A literature review is also conducted to explore the significance of communication and collaboration in serious games. The authors believe that researching related works will help them find what has already been researched as well as identify gaps in the existing literature. This will eventually provide the authors with an overview over the game mechanics utilized in existing games that have been shown to be effective in promoting communication and collaboration while also being enjoyable. This aims to address **RQ1.1**.

3.1 Simulation in Serious Games

The specialization project analyzed various game types and elements, identifying those particularly effective in teaching Agile methodologies. Simulation emerged as a recurring, successful element in teaching Agile, aiding players in learning Agile concepts and how to adapt to various scenarios. This section aims to explore simulation games in greater detail to understand the key elements of a simulation game and how they could help with starting to design the game concept in the upcoming chapter.

In order to understand the use of simulation in serious games, one has to understand what simulation games are. A simulation is “an operating representation of central features of reality.” (Dorn, 1989). Defining it in the context of the game would give us “A simulation game is an exercise that has the basic characteristics of both games and simulations” (Coppard, 1977). Simulation games are designed for many players, where rules are described explicitly and specify which actions are permitted. They also limit and guide the player’s behaviour to ensure

the players succeed or fail in reaching a goal in the same manner as in the real world. In other words, simulation games allow the players to simulate real-world activities and situations in a constrained virtual environment.

Role-playing is a common feature within simulation games. These games are typically designed with an emphasis on player interaction rather than individual roles. The interaction can differ from cooperation to intense competition. The roles assigned to each player may be roles that is rooted in real-world professions, such as a doctor, a president, a spouse, or a software developer. Alternatively, they could also be fictitious roles such as a monster or a devil.

The core of all simulation games is the operating model, a set of selected characteristics of a referent in the real world, and the interrelations between these characteristics (Greenblat & Cathy, 1971). The models operate as in the real world, having a collection of elements representing the real world. It does not only simulate a state at a given time but usually also simulates how the system changes over time. For example, the models can simulate a person, a process, a community, or a social structure. Furthermore, models can be computer simulations, a combination of computer and human players, person-machine, or all-person simulations in which every operation is generated by a human player and the consequences are evaluated by humans (Barton & Richard, 1970). Simulation games do not have to appear precisely like reality but should behave similarly. A simulation game reduces the magnitude of reality to make it more manageable. The model includes only some aspects of reality. Hence, the reality is simplified. Simulation games also serve as a form of entertainment, as seen in titles like Microsoft Flight Simulator ¹ and the Farming Simulator franchise ².

3.1.1 Simulation as an element in Serious Games

Simulation games are mostly known for entertainment purposes, but they also have been used and researched substantially in the context of education and teaching. For instance, research confirms that the principle of learning by exploration in simulation environments can support effective learning (Schwartz et al., 2005), promoting comprehension and the ability to transfer knowledge to different problem-solving situations.

There are various advantages of using simulation for learning. The most prominent claim is that simulation games will increase students' ability to learn and their interest in learning (Bellotti et al., 2013). The immersive and interactive nature of simulation games help capture the learners' attention and motivate them to participate in the learning process. When students are engaged when learning, they are more likely to absorb information and remember it.

Simulation games allow students to face the consequences of the results of the decisions taken or process applied and not just be an observer (Torres & Macedo, 2000). It provides a sense of autonomy and control for students, as they are given

¹<https://www.flightsimulator.com/>

²<https://farming-simulator.com/>

the opportunity to make decisions and see the consequences of their actions. This empowers students to take ownership of their learning and feel more invested in the process. Simulation games also saves a lot of clerical work for learners (Deshpande & Huang, 2011). The learners can try several strategies and focus on the parameters for the strategy. The calculation and presentation of how it is done are left to the game software. This is a more efficient and organized way of learning.

A systematic review of 64 articles on simulation games by De Smale et al. shows a positive effect of simulation games on the achievement of learning objectives in higher education (De Smale et al., 2016). Out of the 29 relevant articles about simulation games, none of them established a negative result. Only three articles showed neutral results. The researcher concluded with three recurring conditions for the successful use of simulations and games: the specificity of the game, the integration of the game in a course, and the role of the instructor.

Challenges of using simulation in games

Implementing simulation games for educational purposes provides several potential benefits, such as experiential learning, collaborative environments, and learner-centric approaches. However, it is not without its own set of unique challenges.

Egenfeldt-Nielsen pointed out various barriers to integrating games and simulations into educational environments (Egenfeldt-Nielsen, 2004). These include time scheduling, physical setting, group expectations, experience with group work, instructor background, genre knowledge, technical issues, instructor preparation, perception of games, group size, and proximity. All these factors contribute to a significant workload for instructors who wish to leverage computer games in their teaching practice and demand a range of skills from the instructor.

According to Lopes et al., when commercial games and simulations are released, their gameplay has been pre-scripted (Lopes & Bidarra, 2011). Game content, rules, narratives, and environments are created during development, primarily as static elements, which can create a rigid experience for dynamic players. Although this design approach allows games and simulations to remain robust, testable, and controllable, it also limits player interaction and can make game outcomes more predictable. In turn, this predictability may reduce the learning effectiveness, as players might exploit successful strategies repeatedly to achieve progress.

In terms of using simulation games in classroom, there are challenges associated with making the switch to this type of pedagogy, particularly in terms of resources such as limited time and grading the workload is a concern (moizer2009). When playing the simulation games, the work that needs to be graded comes in quickly, and students need to progress at the same pace so that feedback given can help them with the game. Another cost is the amount of “coaching” that a student may need, especially for the first time in playing the game. Because stu-

dents are unfamiliar with this approach, playing the game requires instruction in how one can prepare and setup the game. Additionally, once the game begins, the instructor has to also monitor what is being said, as well as make sure that students are sticking to their roles and advocating their assigned perspective.

In conclusion, while simulation games offer many potential for innovative and effective learning experiences, overcoming the numerous challenges associated with their design, implementation, and use is essential for them to realize their full potential in educational settings.

3.1.2 Simulation games in the context of Agile Software Development

From the specialization project (Le & Ngo, 2022) there was conducted a literature review of simulation games used to learn Agile Software Development. The list of papers is shown in Table 3.1. The papers have been divided into categories and game features. The first category is "Teaching scrum with collaborative simulation games", which relates to papers that focus on the use of simulation games specifically for instructing the Scrum methodology and Scrum techniques. In contrast, "Educational Game for Teaching Specific Agile Methods" addresses papers that shift away from the Scrum methodology, emphasizing other particular Agile methods instead. The third category is "Facilitate learning Agile using gamification", which refers to papers that propose using gamification rather than games to facilitate Agile learning.

Additionally, the categories "Game elements" and "Game type" were included to describe the various gamification and game activities used in Agile learning. The category "Game elements" describes the game mechanics and elements used in the papers, whereas the category "Game type" illustrates the game type, technology, and platform for which the game was created.

Limitation

Findings from the literature review reveals that most of the research about serious games for teaching Agile Software Development, primarily focused on the Scrum methodology. However, these studies often lack depth in addressing the overall Agile process, focusing mainly on specific principles and methods. To enhance these efforts, there is therefore a need for a serious games that offer comprehensive learning of Agile principles, methods, and foster an Agile mindset. Furthermore, several studies uses existing entertainment games as an environment to simulate Agile Software Development principles, particularly Scrum. These games includes Minecraft (Oliveira, 2016), Minetest (Steghofer, 2022) and Don't Starve Together (Christensen, 2022).

Additionally, existing serious games for teaching Agile Software Development often face limitations in design, including the need for players to be physically present and limited communication channels, which prevents collaboration and Agile learning. Considering the Agile Manifesto's emphasis on interaction and

Reference	Title
Rodriguez, 2021	Serious games for teaching agile methods: A review of multivocal literature
Wangenheim, 2013	Scrumia—an educational game for teaching scrum in computing courses
Fernandes and Sousa, 2010	Playscrum - a card game to learn the scrum agile method
Gkritsi, 2011	Scrum game: An agile software management game
Bassi, 2016	Scrum sim - a simulation game to learn the scrum agile framework
Lee, 2016	Scrum-x: An interactive and experiential learning platform for teaching scrum
Krivitsky, 2011	Scrum simulation with lego brick
Paasivaara, 2014	Teaching students scrum using lego blocks
Oliveira, 2016	The effectiveness of gamification as a problem-based learning tool on teaching agile project management
Schafer, 2016	Teaching Scrum with Minecraft
Steghofer, 2022	One Block on Top of the Other: Using Minetest to Teach Scrum
Christensen, 2022	Respond to Change or Die: An Educational Scrum Simulation for Distributed Teams
Ammons, 2017b	Scrumify: A software game to introduce agile software development methods
Peeters and Cauwenberghe, 2005	The XP Game Explained
de Vasconcelos et al., 2018	Gamification applied in the teaching of agile scrum methodology
Naik and Jenkins, 2019	Relax, it's a game: Utilising gamification in learning agile scrum software development
al azawi et al., 2016	Educational gamification vs. game based learning: Comparative study

Table 3.1: The table shows the publications included in the literature review after screening

communication, along with the current trend towards remote or hybrid work models (as indicated by the State of Agile report (digital.ai, 2021)), there's a need for games that can facilitate Agile learning in distributed settings.

Many current games for teaching Agile Software Development are designed for specific audiences, often university students, limiting their accessibility for diverse learners. Furthermore, reliance on external technologies like Discord ³, Zoom ⁴ and Trello ⁵ for game functions can cause issues like system downtime. To improve these games, they should be redesigned to be more inclusive, with user-friendly interfaces, tutorials, and customizability. Implementing these communication technologies in-game could also enhance user accessibility.

Common game elements

In addition to simulation, the literature review from the specialization project revealed a variety of game elements that are commonly used in conjunction with simulations as well. These elements contribute to the overall game experience of simulation-based games, enhancing engagement, motivation, and learning outcomes. Some of the common game elements identified in the literature review can be seen in Table 3.2.

Game Element
Instructor / Observer
Points / Currency
Scoring Systems
Levels / Progression
Achievements
Rewards
Challenges and Obstacles
Feedback
Assessment
Social Interaction
Storytelling
Customization / Personalization

Table 3.2: Common game elements used alongside simulation

3.2 Literature review: Method

A quasi-systematic literature review was conducted to investigate game mechanics that engage and motivate players, as well as how collaboration and communica-

³<https://discord.com/>

⁴<https://zoom.us/>

⁵<https://trello.com/>

tion are implemented in existing games. The research method involves a manual search of several research databases for suitable papers. Only the publications deemed relevant by the authors were given in this report.

3.2.1 Data Sources

The articles were searched for and collected from several online databases relevant to the field of Computer Science. These included IEEE Xplore⁶, ScienceDirect⁷, Springer⁸, ResearchGate⁹, and ACM digital library¹⁰.

In addition to the mentioned online databases, Google Scholar¹¹, a search engine that indexes many online databases, was used to identify additional papers from various conferences, journals, and articles that were not included in any of the previously mentioned online databases. The authors individually screened and selected all the papers in this report.

3.2.2 Search and keywords

The initial search query was created by extracting the most important keywords relevant to the research questions to obtain a set of relevant publications on which to base the research.

After reviewing the research questions, the most important keywords discovered were words relating to the categories: serious game, teamwork, and game design factors. The multiple keywords relating to each category are listed in Table 3.3.

Serious game	Teamwork	Game design factors
Serious game	Teamwork	Feature
Game	Collaboration	Element
Game-based learning	Communication	Mechanics
Educational game	Cooperation	Design

Table 3.3: The table shows the chosen keywords from the research questions

Broad terms were employed for searching the online databases when looking for the papers on the mentioned keywords since using narrow terms could potentially result in missing relevant studies that use different terminology or phrasing. By using broad terms, a wider range of studies can be captured, allowing for a more comprehensive search of the literature. However, it's important to note that using such broad terms may also result in retrieving a large number of irrelevant studies, which is why the authors have to carefully screen and select the papers. The final search query ended up being the following:

⁶<https://ieeexplore.ieee.org/>

⁷<https://www.sciencedirect.com/>

⁸<https://link.springer.com/>

⁹<https://www.researchgate.net/>

¹⁰<https://dl.acm.org/>

¹¹<https://scholar.google.com/>

“(‘Serious game’ OR ‘Game’ OR ‘Game-based learning’ OR ‘Educational game’)
AND (‘Teamwork’ OR ‘Collaboration’ OR ‘Communication’ OR ‘Cooperation’)
AND (‘Feature’ OR ‘Element’ OR ‘Mechanics’ OR ‘Design’)”

3.3 Literature review: Results

3.3.1 Communication in Serious Games

Communication, an activity that players explicitly regularly invoke in multiplayer games, is a core element in serious games as it plays an important role in teamwork as well as promoting engagement and learning outcomes among players. Since the success of a team largely depends on how well teammates can coordinate their actions in an efficient manner (Gervits et al., 2016), without effective communication, players may struggle to understand each other’s perspectives and objectives, leading to misunderstandings and conflicts that could hinder progress and overall success in a game. To ensure that the players work together efficiently and achieve their goals, it is therefore needed to incorporate mechanics in a game that facilitate clear and concise communication between players.

Furthermore, to ensure effective communication between players, Toups et al. developed a framework for cooperative communication game mechanics through a grounded theory approach and empirical evidence (Toups et al., 2014). The study investigated various ways in which communication is facilitated in games beyond synchronous verbal communication, such as voice or text chat, by analyzing the various game mechanics selected from 40 cooperative games. The framework provides a systematic classification of cooperative communication game mechanics based on six trees of mechanic types, namely environment-modifying mechanics, automated communication mechanics, immersive mechanics, expressive mechanics, emergent mechanics, and attention-focusing game mechanic. Categorizing these mechanic types helps in understanding the underlying principles and purposes of each type, which can lead to a better understanding for promoting engagement, teamwork, and learning outcomes among players.

Similarly, Stein-böck et al. developed a serious game called “Cologon” to improve and foster communication skills in an inclusive education setting (Stein-böck et al., 2019). The aim of the study was to make it clear that communication is much more than spoken and written words, and therefore designed the game with a chat function and a character avatar that could express emotions, prompting the players to consider the emotional impact of their messages. The game also included mini-games that reinforced communication skills, such as active listening, asking questions, and providing feedback between the players.

Another study employed the use of a game for the development of interpersonal communication skills. Jeuring et al. developed a digital game named “Communicate” that allowed students to simulate interpersonal communication scenarios, make decisions regarding information transmission, and receive graded feedback on learning objectives (Jeuring et al., 2015). The game was well-received

by pharmacy, veterinary, and psychology students, who preferred it over video-based learning methods. The scenarios presented in the game also served as a useful starting point for discussions about recognizing emotional responses and employing alternative communication approaches.

In addition to communication mechanics, effective communication in serious games can also be achieved through debriefing sessions, where players can reflect on their communication and collaboration strategies. In a study by Earle, the popular online game “Among Us” as a platform for teaching group development and cohesion in virtual environments was explored (Earle, 2022). The study was conducted among students in a classroom setting with the aim to explore group dynamics and teach different group and team communication strategies. The study activity consisted of four phases: materials and preparation, procedure, playing, and debriefing. In the materials and preparation phase, the players were expected to be already familiar with the learning concepts. In the procedure phase, the learning concepts and game rules were refreshed to the players, and the students were introduced to how the educational value could be related to the gameplay. The playing phase involved the students participating in a game of Among Us and applying their knowledge of the learning concepts to their interactions with each other through various extra challenges given by the teacher. Finally, in the debriefing phase, the students reflected on their experiences during the game and discussed what they learned about group communication and problem-solving. The study found that this approach, which combined Among Us gameplay with debriefing, was effective in promoting effective communication, group development, and student engagement. Therefore, the study highlights the potential of using game-based learning experiences that incorporate debriefing as a game mechanic to enhance the teaching and learning of group dynamics in virtual environments.

Similarly, Yoshimura conducted a research study to explore the use of game-based learning and gamification to teach communication and conflict resolution skills to students (Yoshimura, 2017). The study aimed to increase students’ self-reflection, skills, and comprehension by developing a semester-long role-playing game. The game mechanics incorporated classroom activities such as assignments being presented as quests, and levels and experience points being used for grading. The game activities were designed to reflect the activities of the classroom. In addition to the gamification of the classroom activities, debriefing was used as a game mechanic. During the debriefing sessions, players were encouraged to reflect on their group dynamics, inter-group dynamics, negotiation strategies, individual actions, and internal reactions. They were also encouraged to discuss how their actions in the game were influenced by previous interactions with other players and how these experiences may affect future conflicts. The study highlights the potential of game-based learning and gamification as effective tools for teaching communication and conflict resolution skills.

3.3.2 Collaboration in Serious Games

Collaboration is a key aspect of many serious games, and it can lead to improved learning outcomes and increased engagement among players. Serious games can promote collaboration by encouraging players to work together towards a common goal, or by assigning different roles and responsibilities to players. In this subsection, we will explore different collaboration mechanics in serious games and examine their impact on player engagement and learning outcomes.

A study by Nussbaum et al. discusses how to enhance collaborative learning and interaction in a group setting (Szewkis et al., 2011). The authors identify six conditions for effective collaboration:

1. **Common Goal:** Everyone in the group should have a shared goal that they're all working towards. This promotes teamwork and learning.
2. **Positive Interdependence:** The group members should depend on each other to achieve their common goal, so they all have to put in effort.
3. **Coordination and Communication:** Members need to talk and work together effectively to reach the goal. They can build on each other's ideas to create a joint understanding.
4. **Individual Accountability:** Everyone has a role to play in solving problems and should contribute to the group's work instead of one person doing all the work.
5. **Awareness:** To collaborate successfully, each person should understand what their group members are thinking and provide feedback to help make decisions.
6. **Joint Rewards:** Rewards should be shared by the group to encourage everyone to work together.

Hämäläinen et al. investigates how different game mechanics used in collaborative three-dimensional (3D) learning games influence the nature of collaboration among players (Hämäläinen et al., 2018). The researchers looked into two types of game roles. The first one is scripted or pre-defined which means that each player has a specific function or set of actions to perform in the game. The tasks and responsibilities linked with these roles are predetermined by the game's design. The second one is emergent or non-scripted, meaning that the roles emerge organically based on the dynamics of the group and the individual behaviors, skills, or decisions of the players. The game mechanics employed to stimulate collaboration in this study were "Complementarity", "Indirect Actions", and "Encrypted Information". "Complementarity" relates to situations where players must coordinate their individual tasks to achieve a common goal. "Indirect Actions" describe scenarios where some players are given information or tasks that necessitate the actions of another player, thereby requiring at least two players for successful task completion. "Encrypted Information" involves scenarios where each player holds unique information crucial for task resolution, prompting players to share their knowledge and form a shared understanding. The study analyzed how these roles affected players' interactions and collaborative problem-solving. The study

involved 15 vocational school students, whose in-game conversations and actions were recorded and analyzed. The results showed differences in the ways students interacted and problem-solved depending on whether their roles were scripted or emergent. This indicates that different game mechanics can lead to varied collaborative activities, a factor that needs to be considered when designing educational games. Hämäläinen et al. continued on the study above and explored the use of game mechanics found in their previous work to design a 3D serious game (Oksanen & Hämäläinen, 2014). The study has two primary objectives: to examine how knowledge about collaborative learning has been applied to game design in past research, and to create a collaborative serious game based on this theoretical knowledge. This study applied the following game mechanics designed to promote collaborative learning: spatial isolation, shared space, shared object, encrypted information, complementary action, indirect action and flexible strategies. The results show that while collaborative games have been useful in education, most have been designed predominantly from a pedagogical perspective, with limited integration of educational theory and game design principles. The study suggests that these games might not be realizing their full potential because of this.

Rauch examined the design of game mechanics for asymmetric cooperation in hybrid social co-located games (Rauch, 2017). These are games that combine physical and digital aspects and are played in the same space, encouraging direct social interaction between players. The research looks at how such games can be designed in a way where players work together towards a common goal but do so using different mechanics. The study argues that asymmetry, where players have different abilities to act or access information, can enhance cooperation and make player performances more complementary. The author presents several experimental game mechanics that involve digital aspects, tested through playtests that elicited strong social interactions. The findings from these playtests contribute to understanding how to best design hybrid cooperative games. The challenges encountered during the design process include maintaining a balance between the digital and tangible aspects of the games and ensuring the games encourage social interactions. The key lessons learned from the playtests were that flexibility and complexity in the rules are appreciated by players. The game mechanics of time pressure were identified as a valuable element for enhancing player involvement and promoting cooperation. The presence of time pressure within the game added a sense of urgency and challenged the players to make quick decisions and prioritize tasks effectively. Similarly, the allocation of distinct roles to players was found to have a significant impact on promoting cooperation.

3.4 Discussion

The process of exploring related works, and particularly the focus on the specialization project, revealed significant insights into the current state of simulation-based serious games. Various gaps were uncovered in the existing games such as the limited emphasis on other Agile methods other than Scrum, and the bias in

the audience which made the games unsuitable for various learners. However, the literature review was not solely focused on identifying the gaps. It also shed light on common game elements that have been used alongside simulation, which have been met with considerable success. These elements, ranging from interactive puzzles to shared tasks, appear to effectively facilitate engagement, communication, and collaboration among players.

Furthermore, the literature review on communication and collaboration highlighted that games can serve as an excellent medium for enhancing these skills. The development of cooperative communication game mechanics, such as the framework developed by Toups et al., provides a valuable resource for future game design. Games like "Cologon" and "Communicate" show how in-game elements can be designed to foster communication skills. Additionally, the effectiveness of debriefing sessions, as demonstrated by the use of the game "Among Us" in Earlie's study, indicates the potential benefits of integrating such mechanisms into future game designs.

Moreover, Hämäläinen et al.'s study provides an interesting perspective on collaborative learning by looking at game roles (scripted and emergent) and various game mechanics. The incorporation of distinct roles and mechanics like "Complementarity", "Indirect Actions", and "Encrypted Information" encourages a high degree of interactivity among players. This interactivity, in turn, leads to a more dynamic learning environment that stimulates problem-solving and strategic thinking.

In conclusion, serious games present a promising avenue for teaching Agile Software Development, communication, and collaboration. The integration of well-designed game mechanics and elements can result in engaging and effective learning experiences. The insights gained from the specialization project and literature review will greatly inform the design process of our serious game concepts.

Chapter 4

Proposed game concept

This chapter describes the design process for the proposed game concepts based on the high-level requirement generated from the specialization project and the findings from the related works. The game design framework used in the game design process will be introduced, along with the four generated learning objectives of the game. From this design phase, three game concepts will be proposed, and one will be selected for further development. Finally, a preliminary evaluation of the chosen concept are conducted.

4.1 Game design framework

Within the context of game design, a framework developed by Alevan et al. (Alevan et al., 2010) serves as a valuable resource for identifying and analyzing crucial design choices during the game design process. This framework, which focuses on educational games, consists of three interconnected components that guide the design process. These components encompass a method for specifying educational objectives, a framework for understanding the mechanics, dynamics, and aesthetics (MDA) of a game, and principles for instructional design rooted in empirical research within the learning sciences. Each of these components provides a solid foundation for creating well-designed educational games and influenced all the decisions made throughout the design process.

The first component of the framework focuses on the establishment of learning objectives, ensuring that the game effectively fulfills its intended purpose. These learning objectives are designed to adhere to the SMART model, which stands for Specific, Measurable, Relevant, and Timely. Specific learning objectives provide clarity and precision in terms of what knowledge or skills the players are expected to acquire. Measurable objectives allow for the assessment of the players' progress and achievement. Relevant objectives ensure that the learning outcomes align with the overall goals of the game and the targeted educational domain. Lastly, timely objectives consider the appropriate timing and sequencing of the learning activities within the game.

The second component of the framework utilizes the MDA (Mechanics, Dynamics, Aesthetics) framework, as introduced by Hunicke et al. (Hunicke et al., 2004). This framework aids in conceptualizing the game as three mutually-dependent layers. Mechanics refer to the rules, actions and systems that define how the game is played and how players interact. Examples of mechanics include scoring systems, movement rules, and combat mechanics. Dynamics, on the other hand, describe the players' behaviors and experiences that emerge from applying the game's mechanics. This includes strategies, social dynamics, and the overall pacing of the gameplay. Lastly, aesthetics capture the subjective experience and emotional response of the players, such as the emotional response or pleasure that the game is designed to bring. A taxonomy of aesthetic elements commonly targeted in games consists of eight items: Sensation, fantasy, narrative, challenge, fellowship, discovery, expression, and submission. The three layers of the MDA framework are interconnected, with game mechanics influencing dynamics, which in turn evoke a specific aesthetic. Players typically experience the game at the aesthetic level, while game designers can only control the game mechanics. The MDA framework allows designers to promote a particular aesthetic goal by making reasoned choices at the mechanical level to achieve the desired aesthetic. A figure depicting the MDA framework by Hunicke et al. can be seen in Figure 4.1.

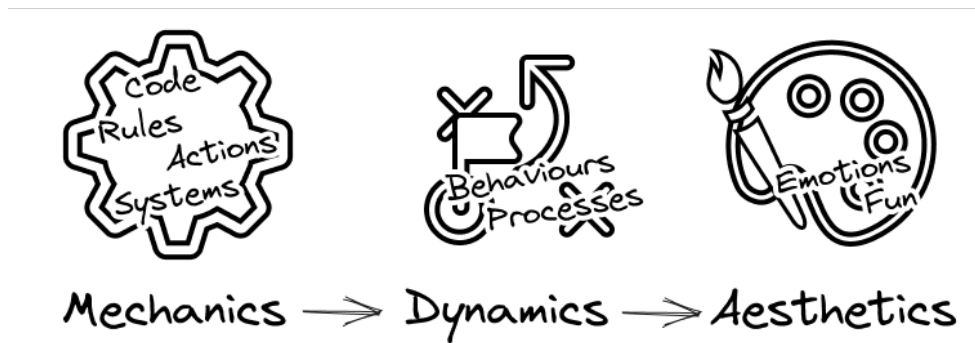


Figure 4.1: MDA framework

The third component is the use of instructional design, which consists of research-based principles. Numerous collections of these principles exist, each essentially summarizing learning sciences for use in educational game design. The assumption is that instructional design principles used in different learning environments will carry over to educational game design. Examples of such collections are Multi-Media Principles by Mayer and Moreno, which provides research-based guidelines for creating instructional materials that combine verbal and visual information (Moreno & Mayer, 1999), and Jim Gee's 36 principles of game-based learning, which describes how learning is supported within standard, commercial, off-the-shelf video games (J. Gee, 2007).

There is no prescribed order or approach for incorporating the three components when initiating the game design. Designers can use each component as a

focus for brainstorming during the initial design, then assess whether the ideas generated while using one component align well with the others. The game design framework outlined in this section will be used throughout the entire design process. The design choices made will be discussed in the following chapter.

4.2 The initial game design

4.2.1 Learning objective

In the specialization project (Le & Ngo, 2022), a set of high-level requirements for designing the game was proposed, as shown in Table 2.2. This thesis aims to develop a collaborative game that teaches Agile Software Development (ASD) in an educational and engaging manner. Agile is a comprehensive methodology with numerous frameworks and methods to learn. However, as discovered in the specialization project, it is believed that focusing on Agile values, principles, and mindset may be more effective. The rationale is that promoting and cultivating the Agile mindset is likely more beneficial than learning a specific tool or concept. As a result, this hypothesis will be tested.

Prior to designing the game, it is necessary to identify the aspects of Agile that the game should teach players. A study conducted by Baham et al. highlights a significant gap in the existing literature on Agile Software Development, specifically the absence of a comprehensive theoretical core that captures the essence of the Agile mindset (Baham & Hirschheim, 2022). Previous studies have tried to employ a mix of existing theories that address different aspects of Agile Software Development. However, none of these approaches inherently capture Agile's unique characteristics, as they are not derived from Agile principles and practices themselves. To address this gap, the study proposes a coherent theoretical core for Agile Software Development that can serve as a foundational framework for future research and studies in the field, encapsulating the central aspects of Agile Software Development.

This study identified and described four core concepts commonly found across virtually all Agile Software Development techniques, such as daily meetings, Test-Driven Development (TDD), and pair programming. Techniques, rather than methods, are used because some studies advocate for measuring techniques over methods, as few teams adopt Agile Software Development methods as a whole. The four core concepts are incremental design and iterative development, inspect and adapt cycle, working cooperatively/collaboratively/in close communication, and continuous customer involvement. Combining these core concepts with the high-level requirements list, the learning objectives used to design the game concepts were derived:

- **LO1:** Get to know the agile project development cycle illustrated through iterative tasks
- **LO2:** Understand the need of close communication with team members as well as the customer

- **LO3:** Acquire decision-making skills, and learn to adapt to changes and taking risks
- **LO4:** Learn to estimate the workload and time

4.2.2 Game elements, learning objectives and how they relate

As described in the previous chapter, studies have shown the success of using simulation in learning games. Therefore, simulation will be incorporated in the game concepts. The players should be in an environment simulated to learn the Agile concepts. This can be done by having characters with specific roles in-game that the players play.

To fully immerse the players in the gameplay, the theme of the simulated environment should be as close to the real-world setting as possible to mimic the reality. First it should be a technology-focused environment, meaning that the game should be situated in for example an office building, data center, or server room. The use of computers, networking equipment, and other IT-related devices should be prominent in the game environment. The game should also have a technical language. This can include terminology related to computer hardware, networking, software, and IT processes. Using realistic technical language can further help immerse the player in the game world and make the experience more authentic. The game will have problem-solving challenges related to solving technical problems, such as fixing a computer, finding bugs in a system, securing a computer system from viruses, or troubleshooting software issues. These challenges can be presented in the form of puzzles or mini-games that the player must complete to progress through the game. Furthermore, customization and upgrades are nice to have. The player should have the ability to customize and upgrade their equipment and tools. This can include upgrading computer hardware, installing new software, or implementing new security measures.

To achieve learning objective **LO1**, simulation is proposed to get the player as close to the real experience as possible. The goal is to let the players work in iteration and give them the possibility to adjust and change their strategy after each. As a result, they are able to improve after each iteration and at the same time get a feel of how project development cycles is done.

The next game element to include in the game concepts is in-game communication. According to learning objective **LO2**, the players has to understand the importance of communication. To promote active communication and progressively communicate better, the game should have some kind of game element that force communication to be able to solve tasks. There should be a voice chat along with a text chat. The voice chat will be the most essential version of the communication aspect. This will allow the game to be played online if sitting together is not an option.

To achieve the learning objective **LO3**. Game mechanics related to time pressure can be used. Incorporation of time constraints to simulate real-world scenarios where development teams must make quick decisions to meet deadlines. For

example, this can be done where each iteration is a milestone that has a time deadline. Another game element that can influence the learning objective is to include randomization and random events in the game. The events can impact the project schedule and scope, forcing the players to adapt and adjust their plans accordingly. Another way to achieve the learning objective is to implement some mechanics to manage the resources. Limit the resources available to the player, such as energy, budget or materials. This will help to encourage creative problem-solving and risk-taking, but also force the players to effectively estimate the workload and time. This relates to learning objective **LO4**. It is also important to implement a feedback system to provide regular feedback on decisions and outcomes made. Doing this will help the players understand the consequences of their actions and improve their decision-making skills. A software project is often team based and to complete it, collaboration is important. The game should encourage collaboration and teamwork by allowing players to work together in a team-based setting and make collective decisions. The game elements proposed above should be included a simulation-based serious game, and the game design process should be centered around these elements.

4.2.3 Motivation

In order to keep the players engaged in the learning process, the game has to incorporate motivators. Understanding the rationale behind what motivates a person will help with the game design process. Giannakos conducted a study to examine factors affecting learning performance (Giannakos, 2013). The study investigated the effectiveness of using educational games to teach mathematics to students. It focused on the effect of students' attitudes on their learning performance. Specifically, the researchers selected three categories: entertainment, acceptance, and emotions - which have been recognized in the literature as important. From each category, they selected one representative variable: enjoyment, intention to use, and happiness, respectively. The researchers aim with the thesis was to explore how these attitudes are connected with learners' performance in educational games. In terms of the entertainment category, the researchers concentrated on the component of enjoyment. They pointed out that there has been little research on the effect of entertainment features in educational games. They do, however, base their work on existing theoretical foundations of entertainment and information systems, which present the aspect of enjoyment as vital for understanding a system's entertainment nature. As a result, the researchers propose that learners' enjoyment of the game has a strong relationship with their performance. In the acceptance category, the researchers focused on the factor of intention to use. Previous research investigated the attitudes and perceptions that encourage students to utilize games for learning, but the relationship between these attitudes and learners' actual performance received less attention. Therefore, the researchers aim were to evaluate whether and how learners' intention to use the game affects their performance. Furthermore, the researchers focused on the happiness factor

in the emotions category. They emphasize the importance of emotions in learning and how pleasant emotions can improve learning outcomes. They hypothesize, however, that learners' happiness with the game has no relationship with their performance.

All in all, even though the results show that the happiness and the intention of use in a game do not have a significant relation with learning performance, it is still important to consider the enjoyment, attitudes and preferences of the players when designing educational games.

Relation of motivation and game mechanics

Understanding the relationship between motivators and game mechanics will aid in determining which game mechanics should be included in the game. Villegas et al. conducted a qualitative research study to assess the relationships between motivators and game mechanics (Villegas et al., 2021). By taking this approach, it is intended that during the design phase of a gamified system, decisions can be made about the design of the system based on the motivators of each of the profiles assessed. First, a large list of game mechanics were extracted from several gamification frameworks. Out of the extracted mechanics, 58 game mechanics that were deemed relevant were chosen by some expert consultants. Following that, the experts consultants are instructed to select the game mechanics they meant would give the most motivation and educational value. For each of the game mechanics the experts were also tasked to link them to the motivators, which were based on the model of the Wheel of motives by Beatriz Valderrama, which shows five motives of approach and five of avoidance (Valderrama, 2018). The motivators can be seen in Table 4.1 and the results showing the 10 most popular game elements are shown in Table 4.2, the percentage indicates the selection rate among the experts consultants. Sharing knowledge comes out on top with a selection rate of 93%. Exploration in 2nd place with 64%. The motive Achievement (55%) is the most selected motives based on the game mechanics with the highest selection rate.

4.3 The game concepts

Following the process of the game design framework, the game design concepts have been created based on the learning objectives. The game elements are basically the same in all three concepts, with the distinctions and differences being the game type and genre, theme, visual style, and plot.

4.3.1 Initial design process

The design process was done in multiple iterations before landing on a final game concept. The game design was done in a digital whiteboard called FigJam¹. The

¹<https://www.figma.com/figjam/>

Approach Motives	
Motives	Explanation
Autonomy	Preference for being independent, following one's own criteria and making decisions for oneself.
Power	Desire to lead others, compete and win, rise, receive admiration, have popularity and prestige.
Achievement	Preference for overcoming challenges, achieving professional success and reaching high standards of excellence.
Exploration	Interest in novelty and variety, seeking to learn and discover new ways of doing things.
Contribution	Desire to help others, contribute to society and have a positive impact on the lives of others.
Avoidance Motives	
Motives	Explanation
Affiliation	Preference for being with others, being part of a group and feeling accepted.
Cooperation	Desire to maintain egalitarian relationships, avoid inequity, and create distance from power, rivalry, and abuse of power.
Hedonism	Preference for saving effort and tension, avoiding sacrificing one's own well-being to pursue goals.
Security	Preference for maintaining the stability of the environment, as well as avoiding changes and uncertainty.
Conservation	Desire to protect oneself, earn money, and conserve material goods.

Table 4.1: Approach and avoidance motives as explained in the wheel of motives

Game Mechanic	Selection rate	Motives
Sharing knowledge	93%	Cooperation
Exploration	64%	Exploration
Gift/Sharing	64%	Contribution
Voting/Voice	64%	Power/Contribution
Boss fights	57%	Power
Competition	57%	Power
Milestone unlocks	57%	Achievement
Miniquests	57%	Exploration
To attend an appointment	57%	Affiliation
To win a reward	57%	Achievement
Build from scratch	50%	Achievement
Challenges	50%	Achievement
Exchangeable points	50%	Cooperation
Group quests	50%	Cooperation
To enhance the identity	50%	Autonomy/Hedonism

Table 4.2: 15 game mechanics linked to the motivators

design process started with an initial brainstorming to generate a large number of ideas and solutions. The goal here was to write down anything related to the game design. This can be elements such as game mechanics, theme or parts of a story. This phase was about encouraging free thinking, creativity, and a non-judgmental attitude towards ideas. Mostly game genre combined with short story of the game was proposed, as shown in Figure 4.2.

The next step was grouping the elements and expanding the initial game ideas. Each idea was described in more detail and explained how it can fulfill each of the learning objective, as seen in Figure 4.3. After each game idea had been detailed, they were ordered after which ideas had the most potential to be further developed to be a good game concept. The first three concepts were chosen to go forward with. The three concepts were detailed out more by specifying the game style, art style, characters and setting/theme. Adding pictures of other games and elements to get a better impression of the game.

4.3.2 The concepts

Concept 1 - Bug finding game

The first concept is a collaborative detective-like game where the scenarios are based on finding bugs in an IT workplace setting. The players' goal is to figure out what and where the bug is by gathering and accumulating clues inside an application. The players are being simulated inside a computer or technology world.

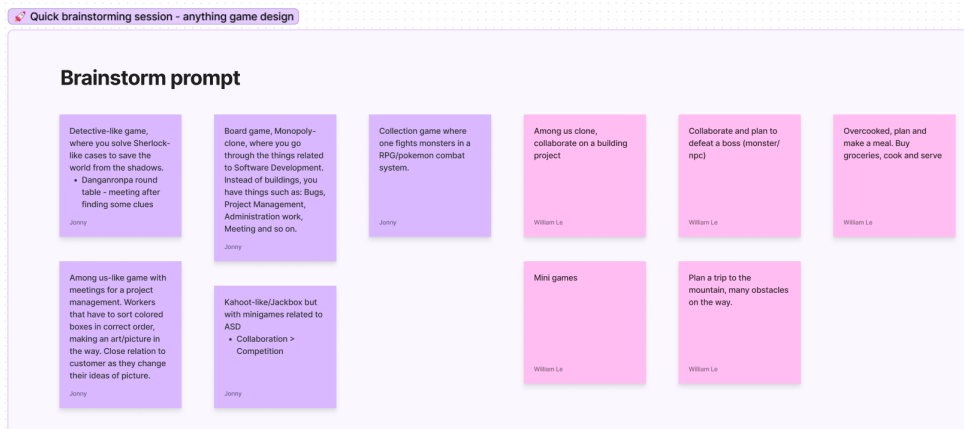


Figure 4.2: Excerpt from the brainstorming session

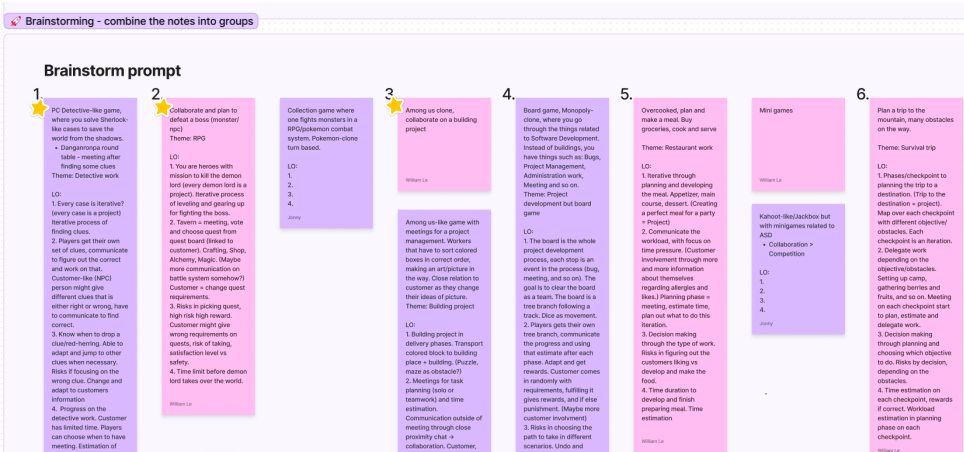


Figure 4.3: Excerpt from the initial game concept ideas

The players gather to discuss and assemble the clues. To successfully address the problem of detecting the correct bug, decisions and priorities must be carefully made and properly determined. The initial state of this first game concept can be seen in Figure 4.4.

How the game fulfill the learning objectives:

1. Every case a project, while finding a clue to solve the case is an iterative process
2. Each player get their own set of clues and they have to communicate to figure out the correct order and if the clue is fake or not
3. Having the player know when to drop a clue. They must be able to adapt and jump to other clues when necessary. There risk will be dependent if the player can tell if a clue is real or fake. Also being able to change and adapt to customers information.

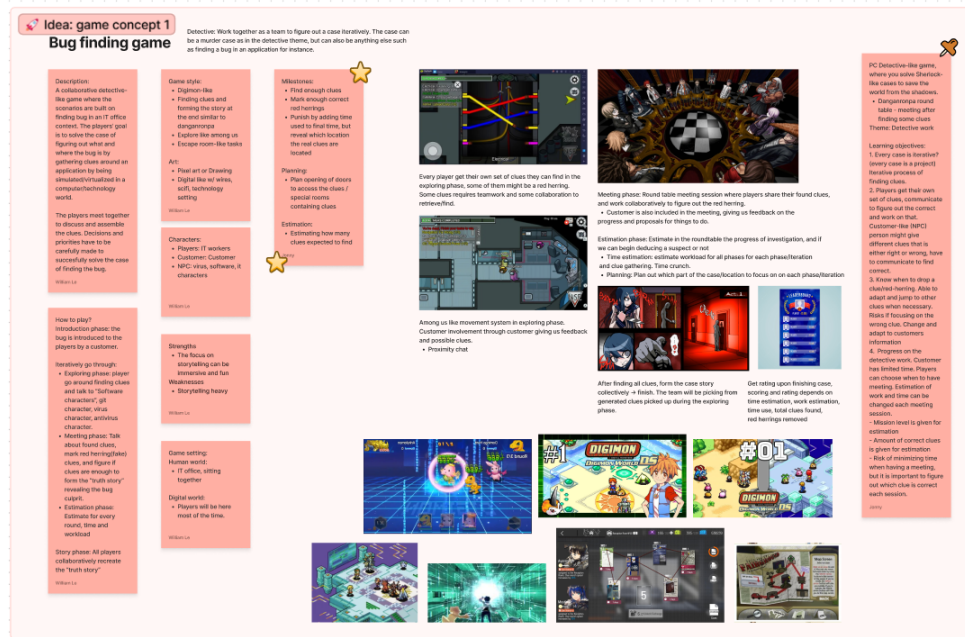


Figure 4.4: Excerpt from the initial state of game concept 1

4. Having progress on the detective work. The customer has limited time. Players can choose when to have meeting. Estimation of work and time can be changed each meeting session

Concept 2

The second concept is a RPG game where you and your team have a goal of finishing a project in time for a customer. To be able to do so, you have to develop yourself by gearing up and have the right stats and experience. To gear up you have to complete small tasks or "quests" to gain experience or rewards. There are meetings to decide and prioritize which quests to do. The term quest can be thought of the same as software issues. Poor prioritization can make the goal harder and take more time to reach. The initial state of this second game concept can be seen in Figure 4.5.

How the game fulfill the learning objectives:

1. The players have a mission to kill the final boss. The iterative process can be incorporated in terms of leveling and gearing up for fighting a final enemy.
2. Having meeting sessions after each iteration where the players vote and choose quests from a quest board. In these sessions the players can coordinate, plan for the next iteration and do retrospects.
3. There is some kind of risks related to picking quest. High risk quests gives high reward but can also slow you down if you are not able to do it.
4. Time limit for the project.



Figure 4.5: Excerpt from the initial state of game concept 2

Concept 3

Collaborative game where a team is set to build an IT product. The product can be a server, framework or software. The product are built using colored blocks. A product has a specific set of blocks and are placed together in a specific order. Blocks are gathered by solving problems or doing exercises. The team has to plan and build the product with limited block resources. Blocks has to be organized into correct order and color according to the "recipe" of the product. The initial state of this third game concept can be seen in Figure 4.6.

How the game fulfill the learning objectives:

1. The team build the product in multiple iterations.
2. Meeting sessions for task planning and time estimation. Meeting with customer who can come with new requirements for the project. For example colors, shape and size.
3. Different ways to gather the colored blocks. Has to prioritize and plan some routes to extract the blocks.
4. Conduct time and workload estimation on each meetings. Also having limited time to build the product will force the player to think thoroughly when estimating.

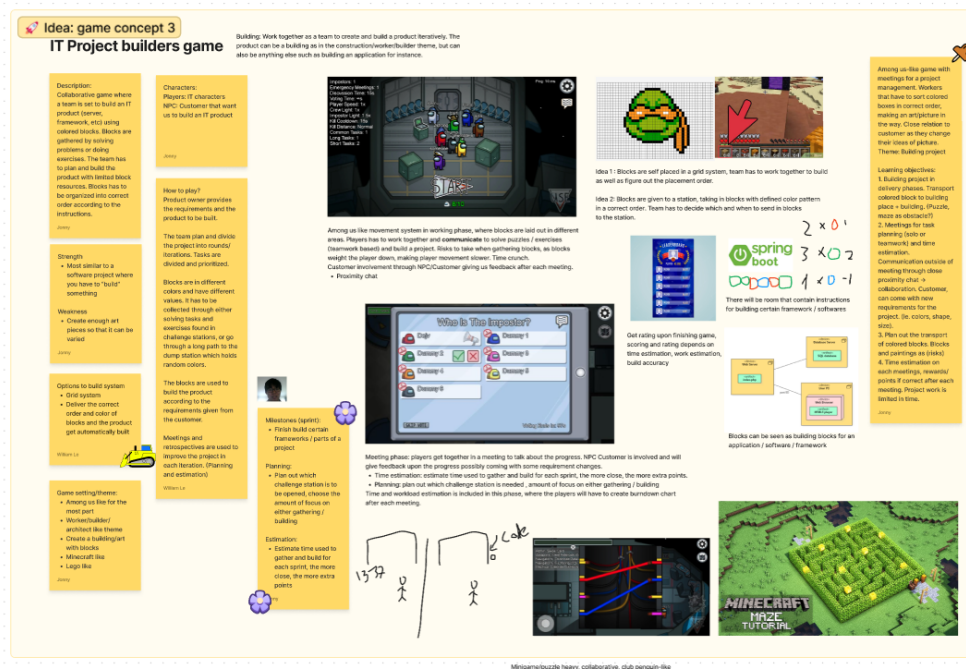


Figure 4.6: Excerpt from the initial state of game concept 3

4.3.3 Chosen game concept

The three game concepts were first presented to the supervisors for a quick feedback. In response, the supervisors advised to make the game concepts as IT related whenever possible and to promote the IT aspects side of the game. An optimal balance between the game and learning aspects of the game is important. It is important to note that the chosen game concept did not need to be limited to one of the three proposed game concepts. Rather, a viable option would be to select the most promising elements from each game concept and combine it into a final game concept. The supervisors also emphasized that the game should be gender neutral and avoid any stereotypes to ensure inclusivity and appeal to a broad audience.

After discussing the feedback from our supervisors, we decided to integrate the most promising game elements from various game concepts into a single, cohesive game concept. From the first game concept (bug-finding game), We had the idea of the players being inside a digital world to work on a project like for example inside a computer. This is in addition to simulate player being already in a realistic environment like the office. From the second game concept (IT project RPG), we were drawn to the role-playing game (RPG) genre, which adds a strategic and dynamic layer to the gameplay. We appreciated the concept of completing subtasks or quests to gain in-game experience and level up one's character attributes, thereby preparing players to be able to do challenges more effectively.

The final game concept can be described as an RPG where players are assigned

a project by a customer to work on as a team. This project takes place within a digital world where players must level up and accumulate in-game experience to overcome monsters disguised as bugs and viruses related to the project. Completing a project does not necessarily involve software-related tasks, such as coding; instead, it may encompass achieving a set of objectives, such as eliminating monsters and doing puzzles. For now, the game concept remains at a high level. More about the learning and engagement elements that can be used to fulfill the learning objectives will be decided in the next phase of game design and is described in the next chapter.

How the game fulfill the learning objectives:

1. The team is doing the project in iterations. Each iteration can include a set of objectives or tasks to be completed. The final iteration can be fighting the end game monster.
2. Meeting sessions for task planning and time estimation. Meeting with customer who can come with new requirements for the project.
3. Prioritize the objectives, wrong prioritization can have consequences.
4. Conduct time and workload estimation on each meetings. Also having limited time to build the product will force the player to think thoroughly when estimating.

4.3.4 The MDA framework

In designing Digital Descent, the MDA framework was utilized to ensure that the game mechanics, dynamics, and aesthetics aligned with the primary learning objectives. The learning objectives were centered around understanding the agile project development cycle, emphasizing close communication, decision-making skills, workload estimation, and time management.

To address the first learning objective, the game was structured in iterations, with each iteration consisting of five days where the players could plan out and select tasks to do for the iteration out of a list of objectives to be completed by the players. The last day of each iteration was dedicated to a meeting with the customer where they are checked if the progression is going good or not.

To address the first learning objective, the game was designed with a structured iterative approach where each iteration spanned five days, during which players were given the opportunity to plan and select tasks from a list of objectives to be completed. The objective of the game was to successfully complete as many of the tasks as possible within the given iteration. At the end of each iteration, a crucial component of the game was a meeting with the customer. This meeting served as a checkpoint or milestone to assess the progress and determine whether the team was on track. The feedback received during these meetings played a significant role in guiding the players' decision-making process and adjusting their strategies for subsequent iterations. This design choice fostered a sense of challenge as players needed to balance their choices between easy and hard tasks, which could yield higher rewards but also posed a risk of failure. The

mechanics of killing monsters and solving quizzes served as examples of objectives that could be attempted with varying degrees of difficulty, providing players with a range of choices to align with their abilities and in-game progression.

To support the second learning objective, close communication was facilitated by in-game chat, voice chat, and through doing the objectives in the game. The challenges were designed to be difficult enough to promote and force communication and collaboration within the team. A task board was also incorporated into the game to aid in coordination and communication among team members. Moreover, players were required to remain together, standing in the same place to interact with game elements, such as entering the portal or opening the task board. This mechanic reinforced the importance of teamwork and collaboration in agile project management.

For the third learning objective, players were exposed to various challenges, such as monsters of different difficulty levels and quizzes of varying complexity. The limited number of days between customer meeting and the step indicator in the Exploration scene provided limited time for players, forcing them to take risks, adapt to changes, and make critical decisions. This dynamic helped players develop their decision-making skills in a challenging environment.

The fourth learning objective focused on workload estimation and time management. An in-game task board was utilized to plan the objectives to be completed, compelling players to estimate the workload and time required for each task. Additionally, the customer meeting held at the end of each iteration played a significant role in addressing workload estimation and time management. During these meetings, players received valuable feedback from the customer, allowing them to evaluate the effectiveness of their task planning and time allocation. This feedback provided a means for players to reflect on their performance, make adjustments to their workload estimation, and improve their time management skills in subsequent iterations. These mechanics emphasized the importance of time management and workload planning in agile projects.

Overall, the MDA framework played a critical role in designing Digital Descent, ensuring that the game mechanics, dynamics, and aesthetics supported the learning objectives and provided a challenging and fun experience for players. By focusing on the agile project development cycle, communication, decision-making, and time management, the game offers an interactive way for players to learn and practice the agile mindset.

Principles of instructional design

This part of game design framework analyzes the game concept to find a clear and logical connection between the game and its ability to promote learning. When examining games, it's helpful to look at the instructional principles they use, as this helps us understand how a game supports learning and if it aligns with the recommendations from learning sciences. Keeping in mind that no single game or instructional method needs to include all principles, the focus should be on under-

standing how the game supports learning through a clear and logical narrative. James Gee's 36 principles of game-based learning, derived from his research on learning in standard and commercial video games, offer a valuable foundation for designing principles that can enhance the game development (J. P. Gee, 2003). Table 4.3 shows the design principles in relation to the game concept.

4.4 Game concept evaluation

This section will describe a preliminary evaluation of the game concept, elaborating on the process and feedback received from the users. This assessment aims to provide an initial understanding of user reactions and measure their interest in the game, which will help with the decision if the game concept is ready to be advanced to the next design phase or if it would need to be reworked.

4.4.1 Purpose

The purpose of this evaluation is to gather rapid, initial feedback from users to assess their interest to the game concept and to determine the potential if this game concept. This evaluation will not focus on the specific details of the game, but rather, serve as an exploratory investigation to determine whether users find the game concept engaging, innovative, and worthy of further development. Furthermore, the overarching goal is to observe users' attitudes toward the game concept, determine their willingness to engage with it further, and identify any potential areas for improvement.

4.4.2 Participants

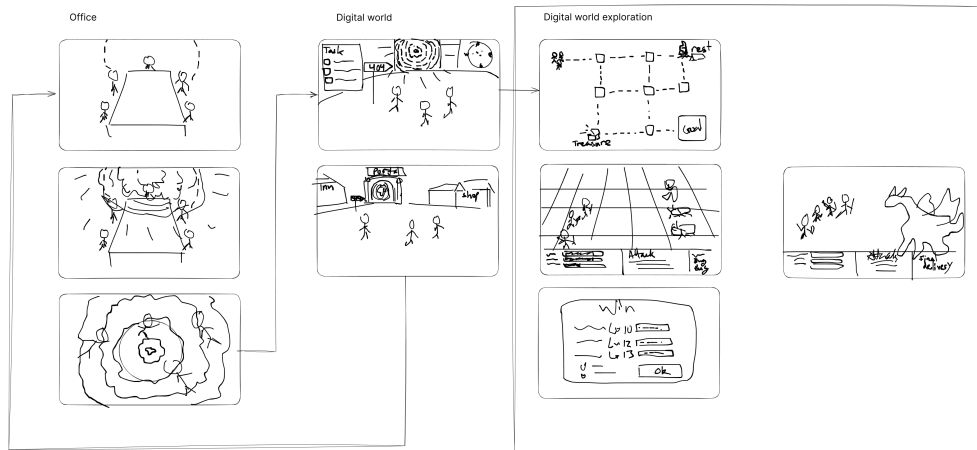
The users recruited for this evaluation comprised two students, selected to represent the main target group. These participants were chosen based on their familiarity with learning games and little experience in Agile, as well as their potential to provide valuable feedback on the game concept.

4.4.3 Process

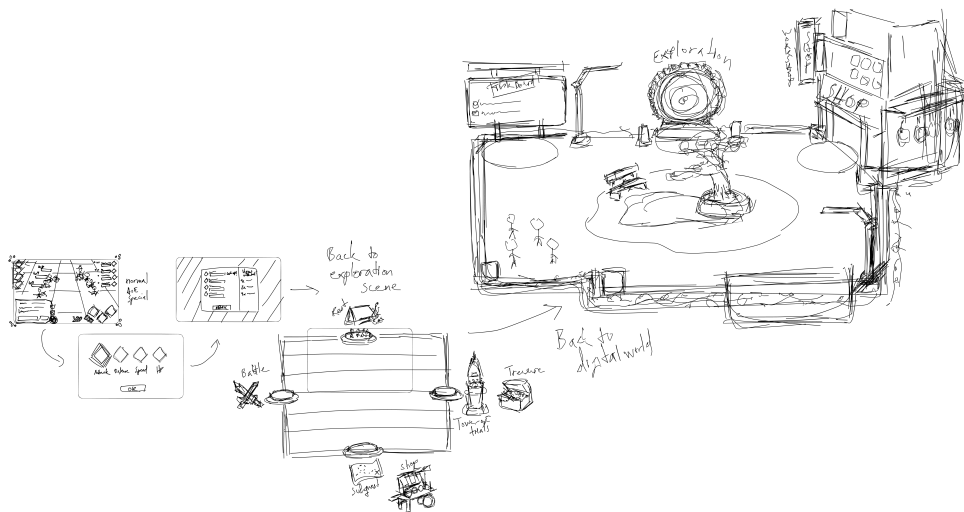
The evaluation process began with a presentation outlining the steps involved in the assessment. Participants were then asked about their experience with learning games and any prior exposure to Agile methodologies. To ensure a comprehensive understanding of the context, a brief introduction to Agile and the learning objectives was provided. This allowed participants to fully grasp the scope and intent of the game concept. Finally, the game concept was presented to the users, highlighting its unique features, game mechanics, and educational components, thus allowing them to engage with the idea and formulate their opinions. Some concept sketches were shown to help participants visualize the game concept. Figure 4.7 depicts these.

Principle	Description
Active, Critical Learning	The game encourages players to actively engage with Agile principles by presenting them with realistic scenarios and challenges that require them to apply these concepts in context. The game supports critical thinking and decision-making by offering different strategies and approaches to solve problems.
Identity	Players control their own in-game avatars where they can explore different roles and responsibilities within an Agile team. This helps learners gain insights into the various positions and tasks involved in Agile methodologies.
Practice	The game provides numerous opportunities for players to actively engage with and practice Agile principles. Through a variety of tasks, dialogues, and interactive elements, players are encouraged to apply and reinforce their understanding of Agile concepts. The game is designed with a focus on iterative learning, aiming to keep learners motivated and engaged throughout the gameplay.
Regime of Competence	The game progressively increases in difficulty as players advance through levels, ensuring that they are consistently challenged but not overwhelmed. This approach allows learners to build their skills and understanding of Agile methodologies at a comfortable pace.
Multiple Routes	As a simulation-based game, the game is designed to cater to various learning styles by providing alternative paths for progression. Players have the flexibility to explore and test their hypotheses by selecting the most suitable course of action. This interactive approach engages players with Agile principles, allowing them to experience the consequences of their choices within a safe and controlled environment.
Intuitive Knowledge	In the game, players have the opportunity to learn from their mistakes and experiences through customer meetings, which serve as evaluation points for their progress. Feedback and guidance provided during these meetings help players refine their progression and deepen their understanding of Agile principles and practices. Players can reflect on their actions, adjust their strategies, and apply their newfound knowledge to improve their performance.
Affinity Group	The game fosters a sense of community among players by incorporating social features, such as a leaderboard, allowing the players to share their experiences and achievements and learn from one another.

Table 4.3: Principles of the Game



(a) The many game scenes and states



(b) The game map's sketches

Figure 4.7: Some concept sketches shown to the participants during the process of the game concept evaluation

4.4.4 Feedback

The testers responded positively to the game concept, expressing enthusiasm for the innovative combination of simulation and RPG elements, which they identified as the most engaging and entertaining aspects based on their previous gaming experiences. They appreciated the incorporation of Agile principles into the gameplay and acknowledged the potential for this game to serve as an effective educational tool. However, they expressed uncertainty regarding the efficacy of merging the proposed game elements in achieving the learning objectives. They were concerned about the potential for information overload, given the game's ambitious scope, and the challenge of balancing entertainment with educational value. They suggested incorporating customizable difficulty levels and learning paths, allowing players to tailor the game to their specific needs and preferences. Furthermore, they also mentioned the challenge of accurately predicting the game's educational impact now because of the absence of a developed prototype. They meant it would be more easy to get a feel of the game if they could a hands on experience of a prototype.

4.4.5 Conclusion

Given the overall positive feedback received, the decision was made to proceed with the game concept. The next steps will involve refining the game design, incorporating the feedback from this preliminary evaluation, and conducting more comprehensive evaluations as the game progresses through various stages of development. Additionally, future evaluations will explore the possibility of including a wider range of participants to gather more diverse perspectives and assess the game's appeal across different target groups. As the game moves forward in its development, attention will be given to ensuring that the gameplay mechanics align with the intended learning objectives, ultimately resulting in an engaging and effective educational tool.

Chapter 5

The game design of Digital Descent

In this chapter, the final game concept is presented to provide a detailed overview of the various design decisions made during the next phase of the design process. This analysis covers essential aspects of the game, including its game loop, target audience, and storyline. Furthermore, the chapter discusses the selection of the game's learning and mechanics, based on the game design framework outlined in the previous chapter. The discussion begins by examining the Mechanics-Dynamics-Aesthetics (MDA) framework, followed by an investigation into the role of instructional design in shaping the educational elements of the game.

5.1 Game description

Digital Descent is a simulation-based role-playing game (RPG) designed to teach and promote the Agile mindset, this includes learning the basics of Agile software Development. Set in a captivating digital world, players form a team up to max eight players and are tasked with completing a customer's project by utilizing Agile methodologies such as working in iterations and continuous improvement to successfully accomplish a set of objectives. The game world is populated with challenges in the form of battling viruses and bugs, which players must overcome to progress in their project. Additionally, players are required to solve quizzes that test their understanding of Agile principles and practices. These challenges also serve as opportunities for players to earn work credits in order to buy in-game rewards that aid in their journey to project completion.

In this simulation, players assume the role of Agile software developers, working collaboratively in a team to deliver the project within the constraints of time and resources. As they navigate the digital environment, they are introduced to Agile values and principles that foster effective collaboration and communication. By engaging in this learning experience, players develop a deeper understanding of Agile methodologies and cultivate the mindset necessary for successful imple-

mentation in real-world software development projects. By immersing players in a dynamic and engaging environment, The game encourages the adoption of the Agile mindset, emphasizing the importance of flexibility, collaboration, and continuous improvement in software development projects.

5.1.1 The game loop

The game loop of Digital Descent comprises three nested loops that encompass various stages of the gameplay experience. The game begins with the "Lobby" state, where players can create a team. From there, players transition into the first loop, the "Start Game/Story Briefing" state. In this stage, players receive an overview of the game's narrative and objectives, as well as access to a tutorial if needed. Upon completing the game, players enter the "Mission Complete/Stats" state, where they can review their performance and progress before returning to the "Start Game/Story Briefing" state for another game.

Within the first loop, a second loop exists, beginning with the "Meeting/Customer Feedback" state. Here, players engage in meetings after each iteration, receiving feedback from the customer and adjusting their strategies accordingly. The loop continues with the "Meeting/Retrospect" state, where players reflect on their performance and identify areas for improvement, before returning to the "Meeting/Customer Feedback" state.

The third and innermost loop focuses on gameplay and character progression. This loop starts with the "Do Tasks/Quests" state, where players battle monsters to complete objectives. Once these tasks are accomplished, players move to the "Collect Experience" state, getting experience points and leveling up their characters. The loop then returns to the "Do Tasks/Quests" state, continuing until players have gained enough experience to face the boss which is another state. After the boss has been defeated, players advance to the "Product Delivered" state, signifying the successful completion of the project. Finally, the game transitions back to the first loop, entering the "Mission Complete/Stats" state which is the end. A visualization of the entire game loop can be seen in Figure 5.1

5.1.2 Starting a game session

Upon opening the game, the player are greeted with the game menu interface, as shown in Figure 5.2, serving as the starting point for players to start playing Digital Descent. To start a game session, one player begin by creating a lobby that serves as a meeting place for the team. This lobby is visible to other players in a list, allowing them to browse available sessions and join. Within the lobby, players have access to a chat feature which also will be available throughout the game to facilitate communication and collaboration among team members. Additionally, it was planned to include a designated area for observers in lobby, enabling non-playing individuals to monitor the game session and learn from the players' experiences or be an additional supervisor. This, however, was not implemented due to the project's time constraints.

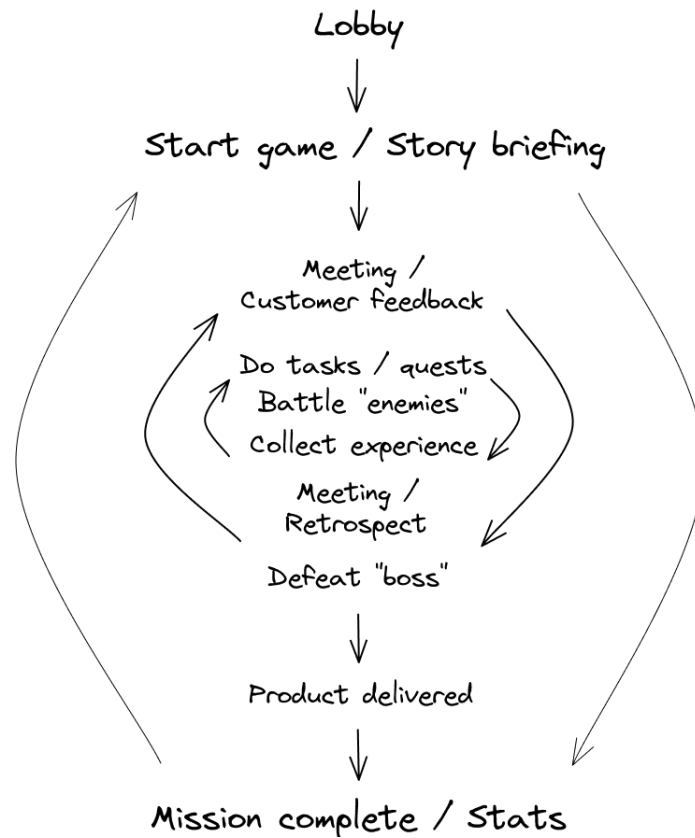


Figure 5.1: A graphic representation of the game loop

The game session starts once all players have joined the lobby and indicated their readiness by clicking the "ready" button, as seen in Figure 5.3. The assembled team is then transported into the virtual world of Digital Descent.

5.1.3 Playing the game

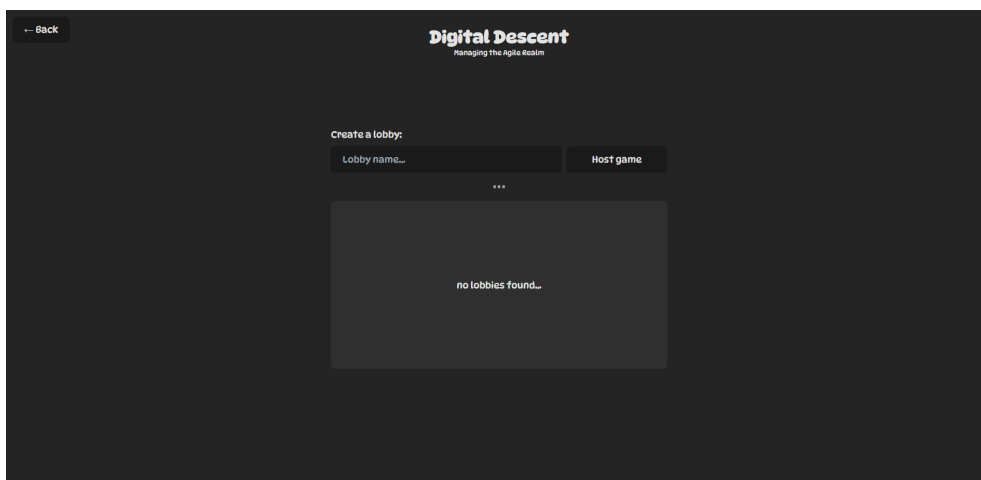
Upon entering the game world of Digital Descent players are able to move around their surroundings using the arrow keys. First-time players go through a tutorial to familiarize them with the game's mechanics and objectives. The starting point for all players is the Office room where the team will be given the project to work on.

Another key location within the game is the digital world, a large and open area where players can roam freely, strategize with teammates, and plan their next action. This space fosters collaboration and communication among players, encouraging them to share insights and coordinate their plan as they progress through the game.

The exploration scene is a third essential location within the game, where players actively work on tasks and objectives related to the customer's project. This

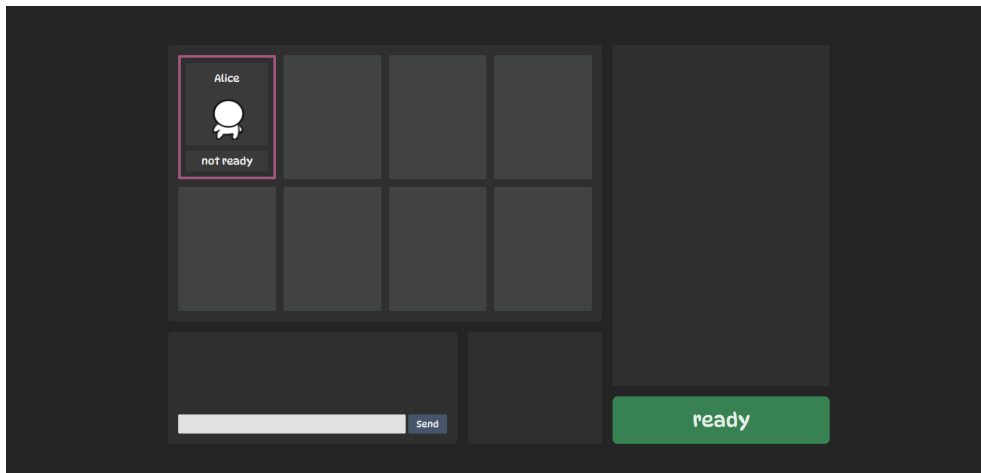


(a) The initial game interface

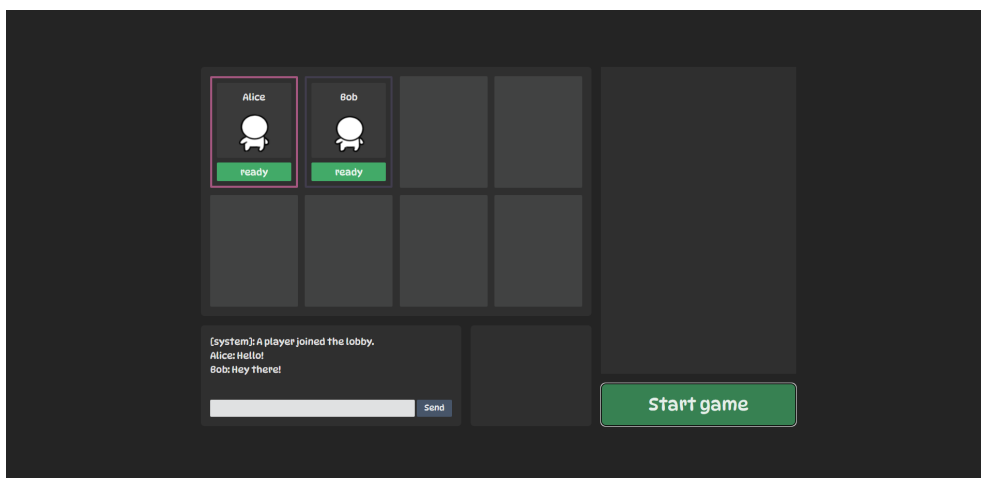


(b) The game interface displaying the available game lobbies

Figure 5.2: Game menu interfaces



(a) A newly created game lobby with no additional players



(b) Players in a lobby that is all ready

Figure 5.3: Game lobby interfaces

dynamic environment presents players with a variety of challenges and scenarios that test their understanding of Agile principles and their ability to apply these concepts in practice. More detail on the different places will be described under.

Tutorial

As shown in Figure 5.4, the tutorial phase serves as an introductory segment for new players, guiding them through the game's fundamental aspects and ensuring a smooth and enjoyable learning experience. Players begin their journey in the Office room, where they are introduced to the team lead, a virtual guide who assists them throughout the gameplay. Communication with the team lead occurs through dialogue pop-ups that appear at the bottom of the screen, providing players with valuable tips and Agile lessons as they progress. Here, the players also meet the customer and choose their role in the team.

After picking a role and transported to the digital world, players are tasked with completing a series of objectives that involve exploring various locations within the digital world. At each significant place, a dialogue pop-up emerges, explaining the purpose of the location and offering guidance on how to interact with it effectively. By following these objectives and engaging with the team lead's instructions, players gain a comprehensive understanding of the game's mechanics, controls, and environments, as well as a foundational knowledge of Agile principles.

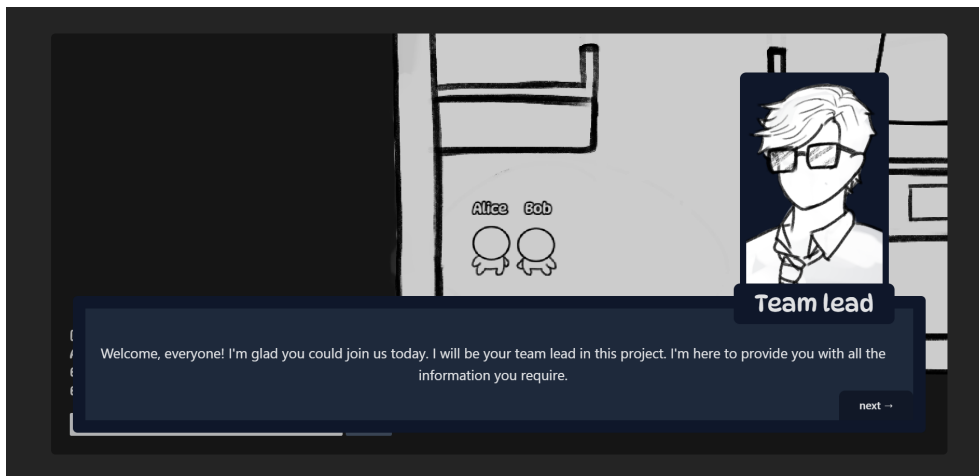
Office

The Office Scene, as seen in Figure 5.5, serves as the central hub and starting point for the players. This virtual workspace is designed to replicate a real-world office environment, creating a sense of familiarity and immersion for players as they navigate the game. The Office plays a crucial role in facilitating communication and collaboration among team members and the customer. The Office provides a space for players and customers to plan their strategies and elicit project requirements. The Office also serves as the primary location for interactions with the customer, who offers feedback to players as they complete tasks and objectives.

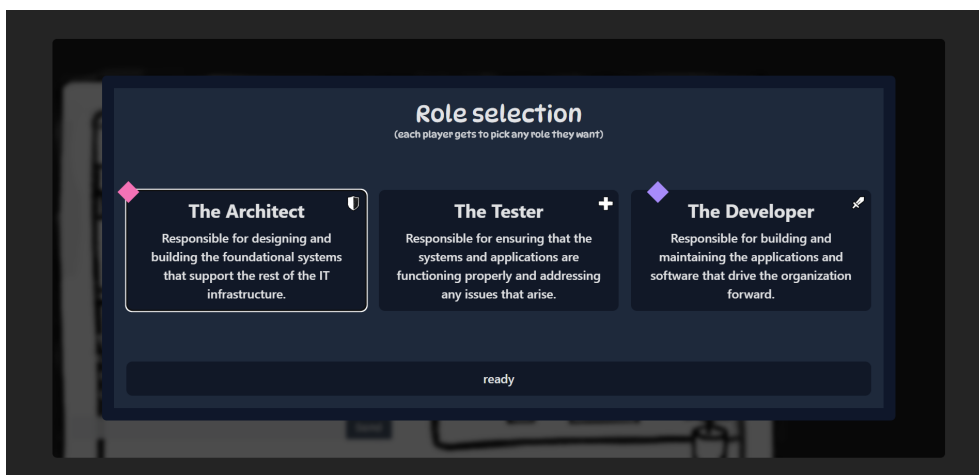
Digital world

The Digital World Scene, as seen in Figure 5.6, represents an immersive area within the game, where players find themselves "inside" their computer. This place serves as a gathering point and planning area offering a space for players to strategize, coordinate, and prepare for upcoming tasks and objectives. Each iteration of the project is set to be five days, where you are tasked to work most of the days except the last day which is reserved for meeting with the customer to show the progress.

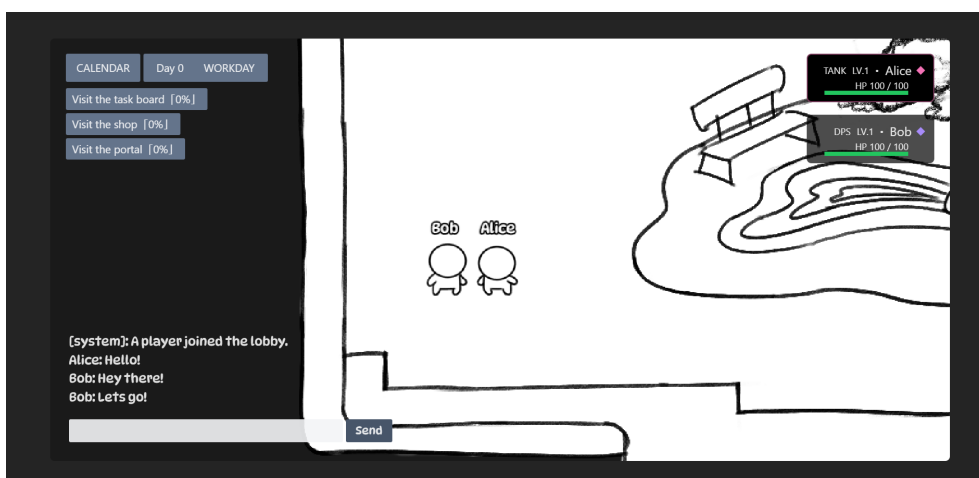
Three main points of interest can be found within the Digital World: the Task Board, the Shop, and the Portal. The Task Board is designed to resemble a Kan-



(a) Dialogue pop-ups



(b) Players are given the option of choosing the roles on the team



(c) The first three objectives given to the players during the tutorial phase

Figure 5.4: The tutorial phase

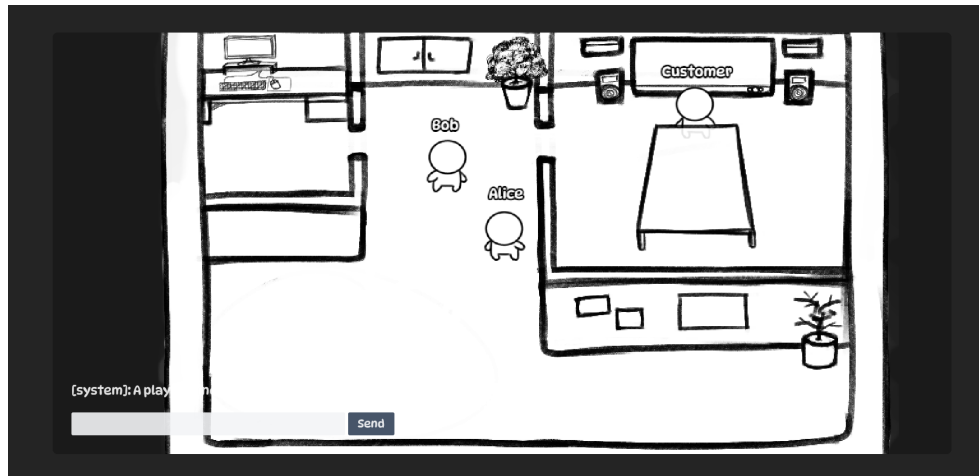


Figure 5.5: The Office scene

ban board, where players can view the backlog which is a list of objectives. The players can drag and drop tasks they plan to work on, and move completed tasks to the "finished" column. This interactive feature allows players to manage their workload and track their progress effectively.

The Shop was planned to offer players the opportunity to purchase a variety of consumable items, such as energy drinks, rubber ducks, mechanical keyboards, and ergonomic equipment, using work credits earned by completing objectives. These items serve to enhance the player's abilities and support their progress throughout the project, enabling more efficient and effective teamwork. Unfortunately, due to time constraints, the shop's functionalities were not fully developed on time.

Lastly, the Portal allows players to transition into project-related activities. Before entering, players can choose between the "work" option, or the "delivery" option, where they present their completed work to the customer. The Portal serves as a gateway to the exploration scene, where players apply their Agile knowledge and skills to finish the chosen objectives from the task board. The three stations and interest points can be seen in 5.7

Exploration

The Exploration Scene, as seen in Figure 5.8, is a place where players access through the Portal stationed in the Digital World after picking the option of "work". In this area, players can choose to explore four distinct locations which are randomized for every step taken during the exploration, offering different opportunities for the players to apply and test their Agile knowledge and skills. Figure 5.9 shows the three visual images displayed in the four distinct locations indicating the type of location.

As shown in Figure 5.10, the major type of location the player gets to explore is

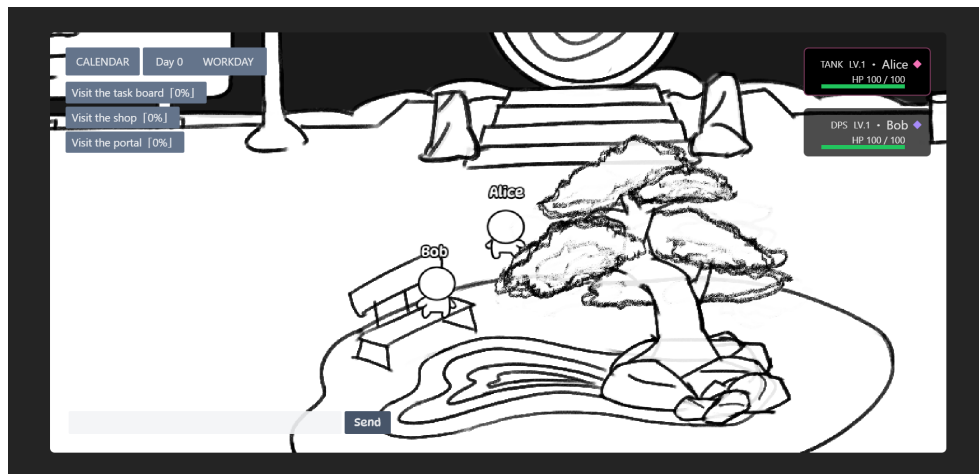


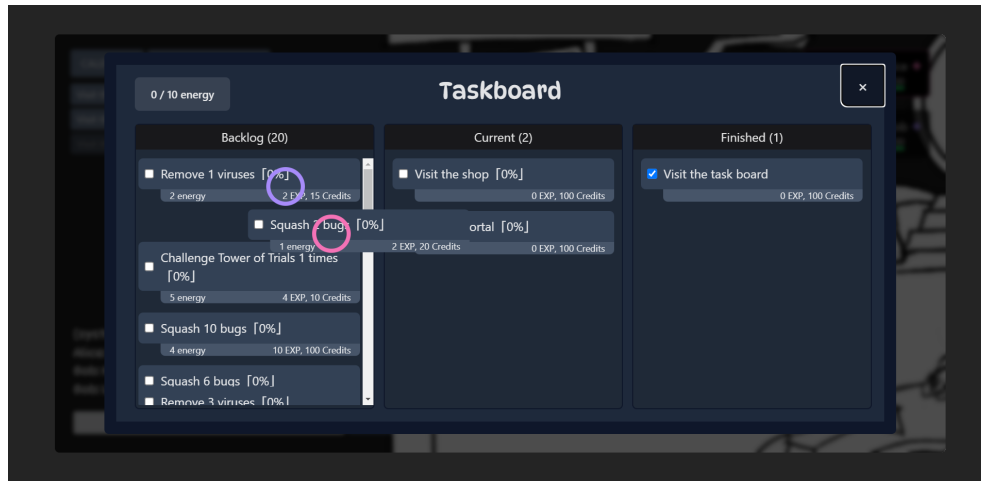
Figure 5.6: The Digital World scene

Battle, where the player is pitted against various monsters using their role-specific abilities in battle. Each role chosen in the tutorial phase has their own three distinct abilities that are strongly tied to the IT context. For example, one of the roles, Developer, has the skills "patch" as the standard normal attack, "test suite" as the charge attack, and "refactoring" as the special attack, each of which causes various damage and consumes different amounts of charge points depending on the attack type. Charge points are earned through normal attacks, and are a vital resource that may be carefully used to obtain an advantage in battle by allowing the player to perform several types of abilities, such as the previously stated charge and special attack. After each successful battle, players level up and can allocate points to different stats, including HP, attack and defense. These battles serve as the primary goal or objective that a player must complete in the game.

Another location a player can explore is the Rest location where players have the option to skip a step, keeping in mind that each exploration workday consists of three steps. Choosing to rest replenishes the player's HP levels, allowing them to recover and prepare for the next location.

Lastly the Tower of Trials, offers players a series of quizzes that test their Agile knowledge acquired throughout the game. Each quiz features four answer choices, with one correct option. These quizzes may also serve as objectives for the project, providing an alternative to battling monsters. Figure 5.11 illustrates an example of a quiz question set, giving a glimpse into the type of challenges one can expect within the Tower of Trials.

The Exploration Scene is a dynamic and interactive environment that encourages players to apply their Agile knowledge and develop their skills through various challenges and activities, fostering an engaging and educational gameplay experience.



(a) The first station: Task Board



(b) The second station: Portal



(c) The third station: Shop

Figure 5.7: The three interest of points stationed in the Digital World

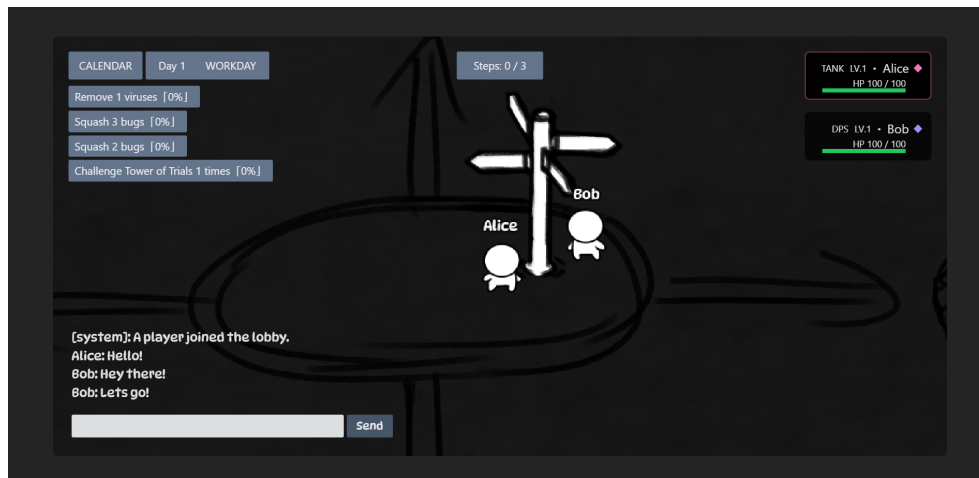


Figure 5.8: The Exploration scene



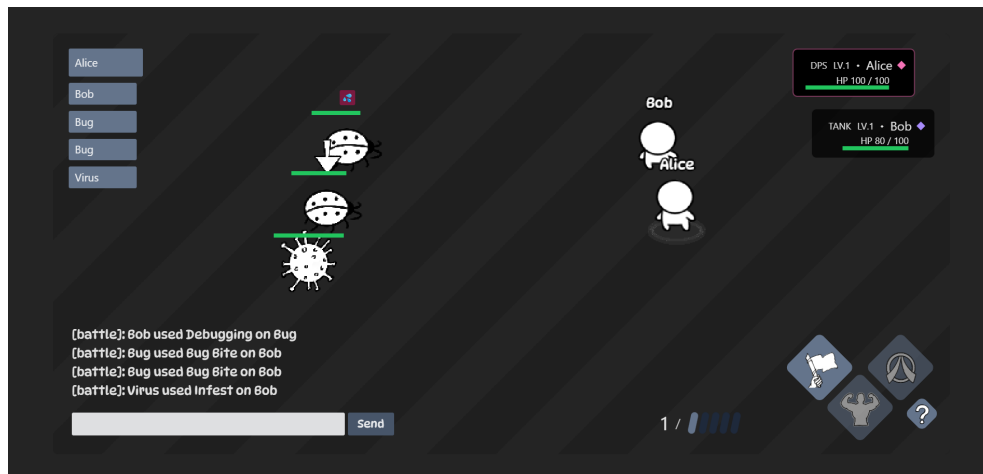
Figure 5.9: The three randomized locations in Exploration

5.1.4 Target Audience

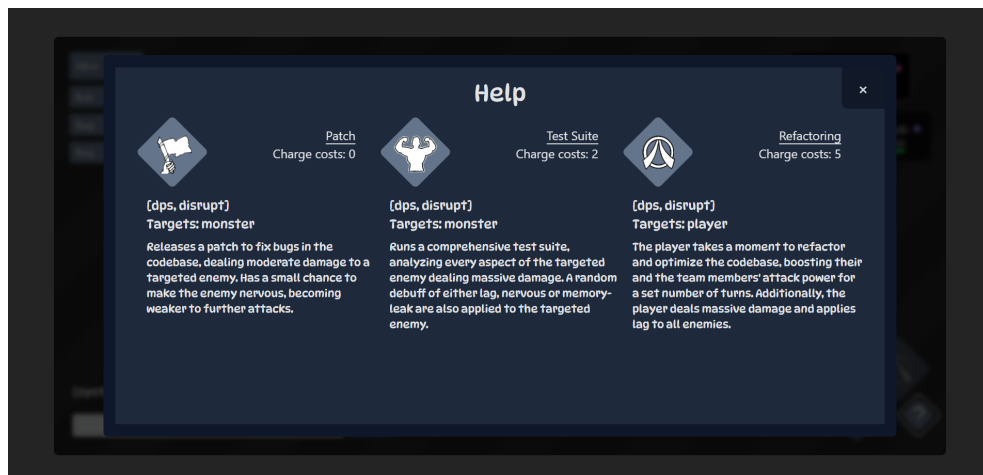
The primary target audience for the game consists of individuals with limited or no prior experience in Agile methodologies who want to learn and practice the Agile mindset.

Students studying IT-related disciplines form a significant portion of the target audience, as the game offers an opportunity for them to gain hands-on experience with Agile principles and practices in a simulated environment. Through participating and playing the game, these students can develop a foundational understanding of Agile methodologies, which can contribute to their academic and professional growth. New graduates entering the IT industry can also benefit from Digital Descent. As Agile methodologies continue to gain prominence in the IT industry, acquiring a practical understanding of these concepts can be advantageous for recent graduates seeking to differentiate themselves in the job market.

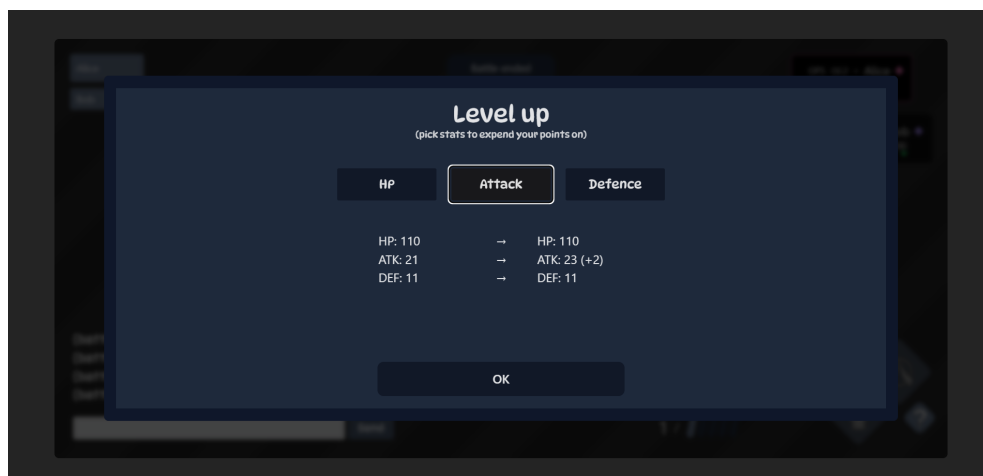
Additionally, individuals who work indirectly with IT but are interested in learning Agile methodologies can also benefit from playing the game. This group may include professionals in other fields, such as project management or business analysis, who wish to expand their skill-set and adapt to the IT industry. By target-



(a) The battle interface



(b) The help interface during battle providing a comprehensive display of the player's role-specific abilities



(c) The interface after leveling up in a battle

Figure 5.10: The Battle scene

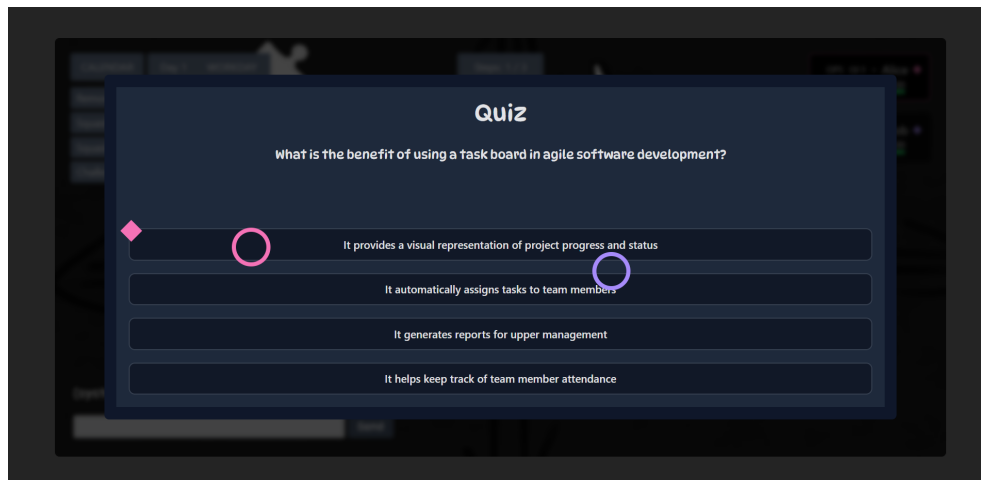


Figure 5.11: One of the many quiz question set in the Tower of Trials

ing a diverse audience of students, new graduates, and professionals, the game aims to promote a detailed understanding of the Agile methodology and foster an Agile mindset among its players and contribute to their personal and professional development.

5.1.5 Overview of the game mechanics and learning mechanics

To make it more structured, Table 5.1 shows the game mechanics and learning mechanics chosen for the game.

Learning Mechanics	Game Mechanics
Instructional	Role playing
Guidance	Collaboration
Action / Task List	Strategy / Planning
Feedback	Capture / Eliminate
Question and answers	Time pressure
Repetition	Movement
Plan	Rewards / Penalty
Experimentation	Action points
Reflect / discuss	Game turns
Tutorial	Leaderboard
Ownership	Stat points / Experience points
Responsibility	Credits
Resource management	Chat
Progress visualization	Boss fights

Table 5.1: Learning and Game Mechanics

Chapter 6

Technical description

This chapter provides a detailed technical description of Digital Descent, a serious game designed to facilitate the teaching of Agile Software Development. We delve into the game's architecture, encompassing the utilization of various architectural and design patterns, as well as the underlying design and technology choices. Furthermore, the chapter provides insights into the development methodology followed and the game implementation process. The source code is available under the MIT license at <https://github.com/shirajuki/digital-descent>.

6.1 Game Architecture

The game Digital Descent was purposefully designed to be a web-based game that could be accessed through standard web browsers, eliminating the need for complex installations or high system requirements. This deliberate design choice allowed for easy access and ensured a broad reach across multiple devices. The game's architecture was, therefore, built to be lightweight and easily accessible. The architecture was also carefully designed to allow for real-time interaction between the client and server components due to the game's collaborative nature and the fact that it is also a multiplayer game. Given the project's time constraints, careful consideration was given to selecting appropriate technologies that corresponded with the desired architectural goals. The technologies used were evaluated based on their ease of use, performance and the capacity to enable the real-time interaction and synchronization required for a multiplayer experience. The game Digital Descent can be accessed and played in the web browser on the URL <https://shirajuki.github.io/digital-descent>.

In the following subsections, drawing inspiration from the 4+1 Architectural View Model by Kruchten, we will describe the various architectural views that capture different aspects of the game (Kruchten, 1995). This includes the logical view, process view, physical view, and the development view, which collectively provide a comprehensive understanding of the game's structure, behavior, and interaction between its various components.

6.1.1 Logical View

The logical view of the game architecture in Digital Descent presents a high-level representation of the game's abstractions, entities, and their relationships. Figure 6.1 presents a class diagram that illustrates the logical view, specifically focusing on the client/server pattern employed in Digital Descent.

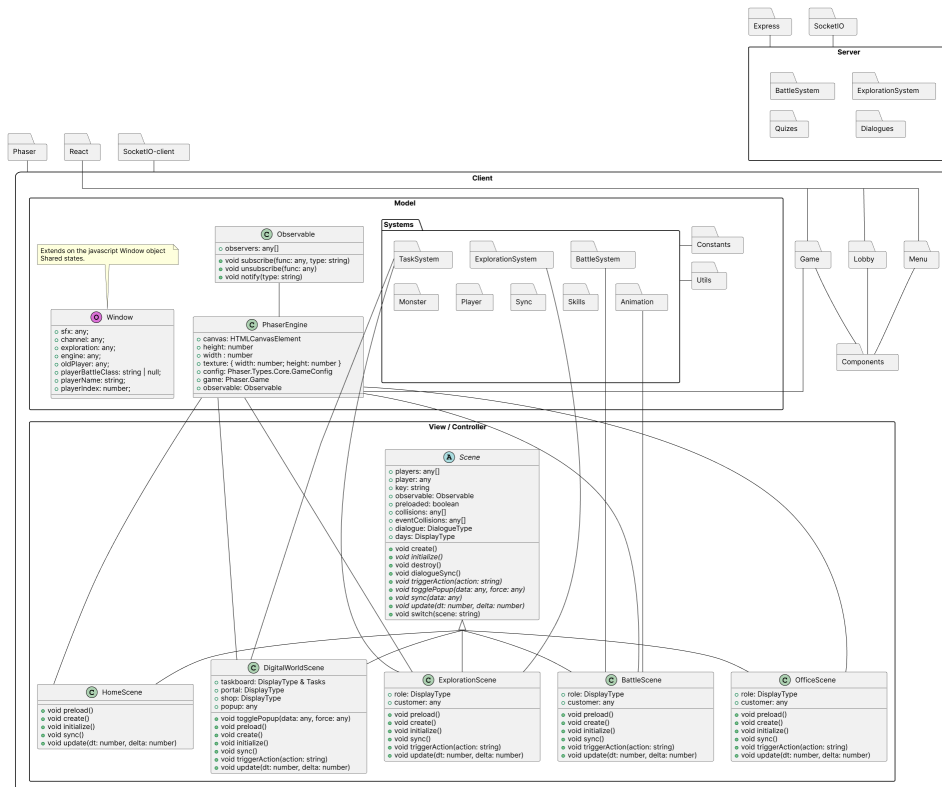


Figure 6.1: Class Diagram showcasing the client/server pattern in Digital Descent

On the client side, the model component contains the game's basic logic and data structures, which includes the game's components, systems, and utilities to offer the necessary functionality for gameplay. Following that, the view layer, responsible for the game presentation, contains the logic for rendering the game scenes and the graphical user interface. Acting as the intermediary, the controller layer facilitates the communication between the model and views, and updates the client state based on user input and game events. Together, these components form a cohesive Model-View-Controller structure, allowing for efficient management and separation of concerns within the client-side architecture. Additionally, the server components in charge of game state synchronization and multiplayer interactions are included in the logical view. These components employ the Publish-Subscriber pattern in order to establish bidirectional communication between the client and server, enabling real-time data exchange and updates. The key element

that is shown in the figure are the clear distribution of responsibilities between the client and server components.

6.1.2 Process View

The process view of the game architecture in Digital Descent focuses on the dynamic aspects of the system, illustrating the interactions, flow of control, and state transitions in the game. Figure 6.1 presents an activity diagram that provides an overview over the game view and state transitions based on user inputs. The diagram presents the major stages of the game, from the main menu to the lobby and into gameplay,

The activity diagram begins with the player launching the game, taking them to the main menu where they can either start and host a new lobby or join another player's lobby. The diagram then shows the transition to the lobby state, and when once all the players have joined and ready, the game transitions to the gameplay state after the "start game"-button is clicked by the game host. Throughout the gameplay state, the diagram captures potential events such as collisions, dialogues, or other game state conditions. Based on these events, the player may transition to different states, such as moving to different level scenes. The diagram visualizes the various possibilities and the corresponding state transitions.

To further illustrate and provide a clear representation of the communication flow between the entities of player, client, and server during the game setup process, a sequence diagram showcasing the interaction while highlighting the Publish-Subscriber pattern used in Digital Descent can be seen in Figure 6.3.

The sequence begins with the player initiating the game setup by clicking the "Play" button on the client-side. The client then sends a request to the server in order to retrieve the list on the available game lobbies. The client, upon receiving a response back from the server, displays the list on the lobbies to the player. From here on out, the player can either choose to host a new lobby or join another player's lobby if available. The client will then send a request to the server and update its state accordingly, proceeding to transition to the lobby state. The player is then notified of the successful setup and is ready to interact with the lobby, where they can wait for players to join or start the game.

6.1.3 Physical View

The physical view of the game architecture in Digital Descent provides an overview of the deployment and distribution of its components across different hardware and software components. Figure 6.4 showcases a deployment diagram that represents the physical view of Digital Descent. The diagram outlines the various component nodes on both the client and server, and how the game's components are distributed and interact within the system.

The deployment diagram highlights the following key components:

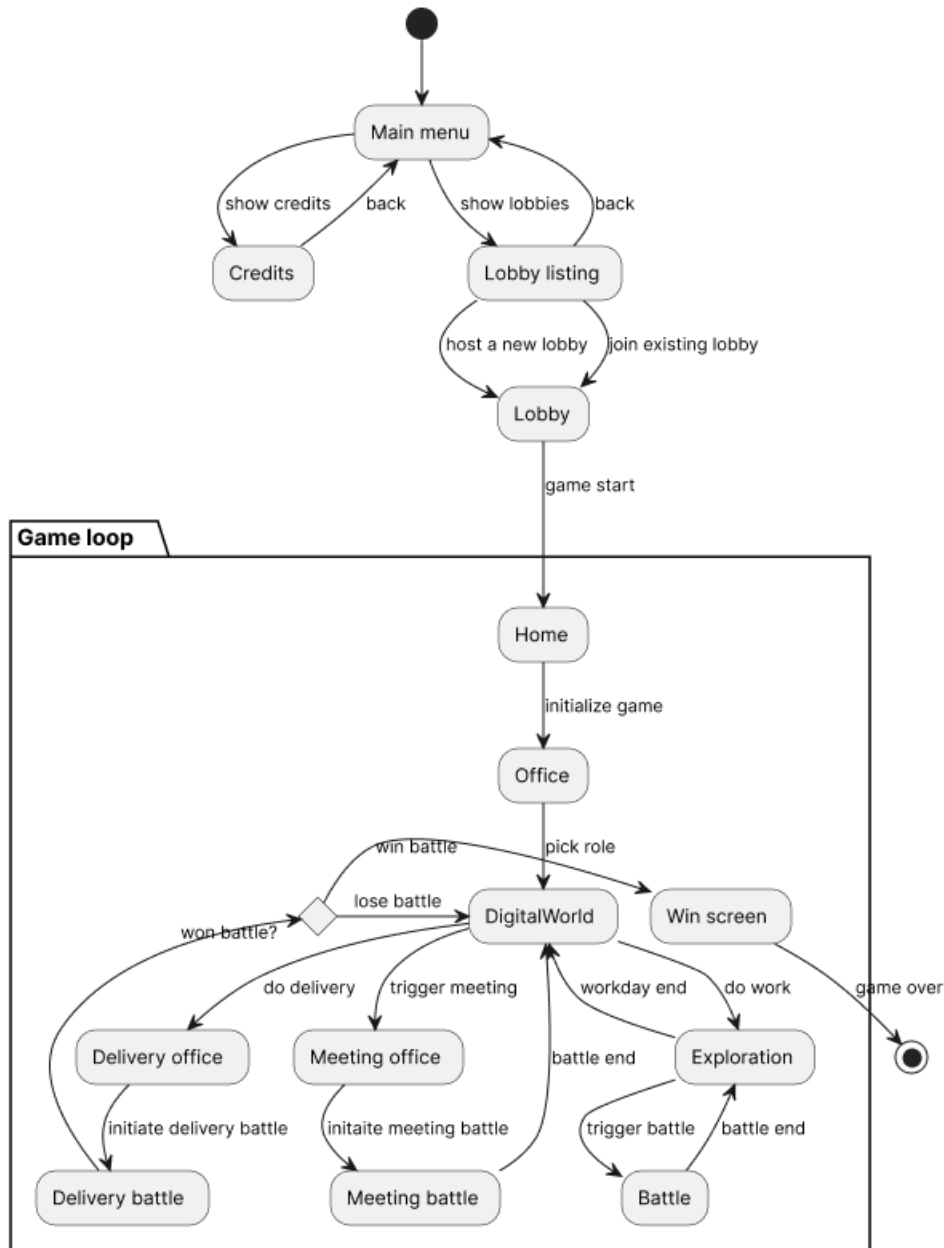


Figure 6.2: Activity Diagram showcasing user interactions in Digital Descent

- **Client Node (UserClient):** Represents the hardware or device where the client-side components of Digital Descent are deployed.
- **Server Node (WebServer):** Represents the hardware or server infrastructure where the server-side components of Digital Descent are deployed.
- **Node Server (Node.js):** Refers to the server-side execution environment responsible for the creation of a game server as well as managing the game

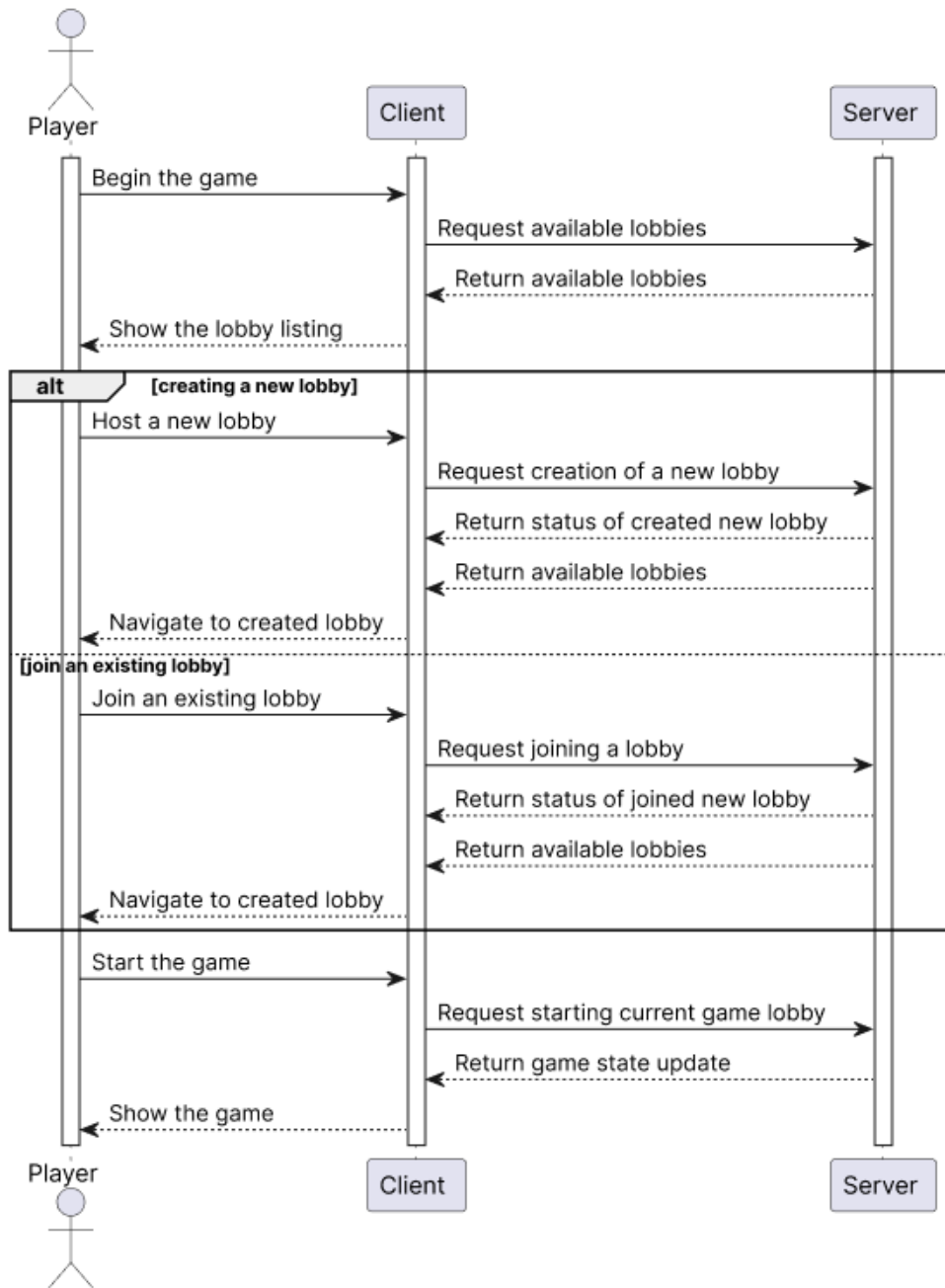


Figure 6.3: Sequence Diagram showcasing the game setup interactions in Digital Descent

logic and handling bidirectional communication between the clients and the server.

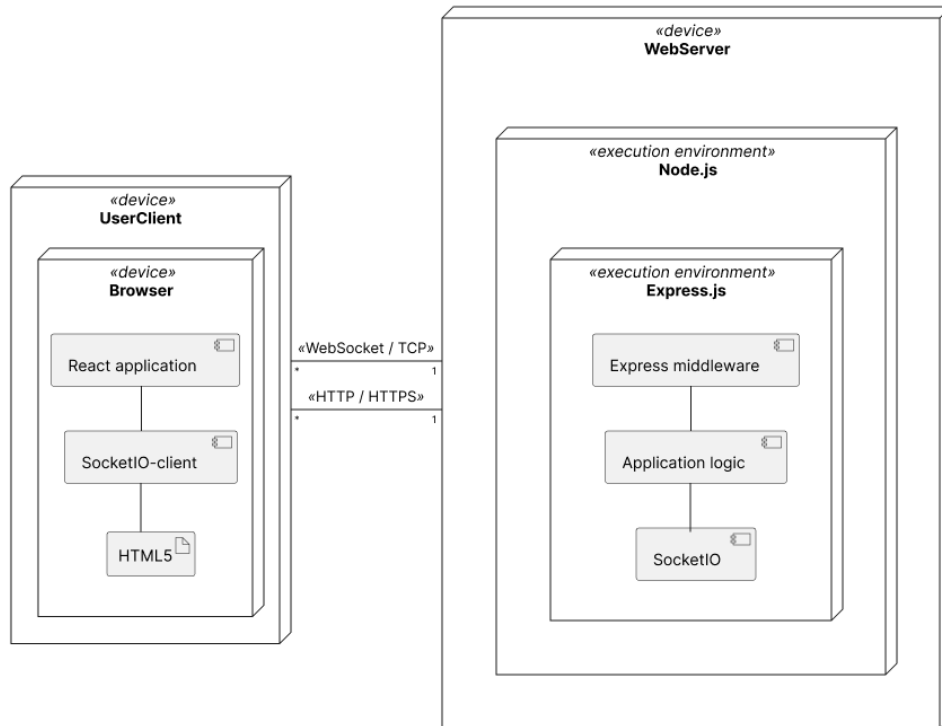


Figure 6.4: Deployment Diagram for Digital Descent

6.1.4 Development View

The development view of the game architecture in Digital Descent focuses on the organization and structure of its components from a development perspective. Figure 6.5 showcases the package diagram that represents the development view of Digital Descent, and illustrates the different modules within the game and how they are organized and interconnected.

The established structure illustrated in the figure enables efficient development, maintenance, and updates, allowing for easy integration of new features and enhancements of Digital Descent, as each component can be independently developed while maintaining tight coupling with the rest of the system. The package diagram highlights the following key components:

- **Game Engine:** Represents the core game engine module that provides the underlying framework for Digital Descent. It encapsulates functionalities such as rendering logic, handling input and managing game states.
- **User Interface:** Refers to the module responsible for managing the user interface elements in the game, including menus, dialogues, HUD (Heads-Up Display), and other graphical elements. It handles the presentation and interaction with the player through the use of React components.
- **Network Logic:** On the server-side, the network logic represents the mod-

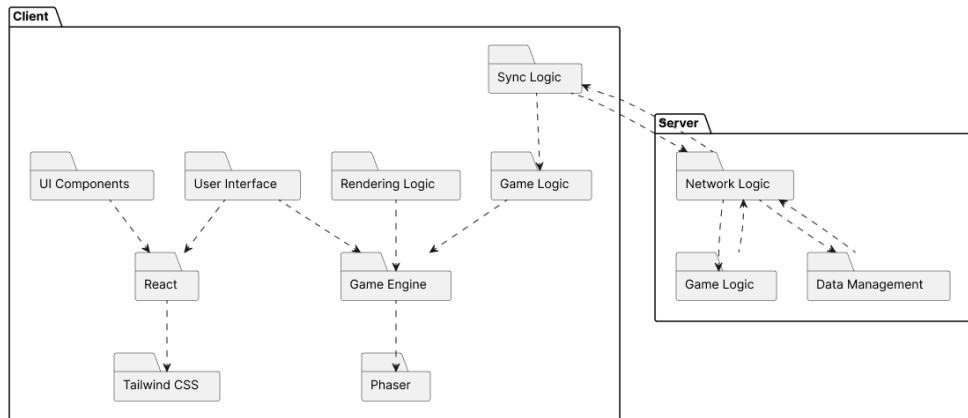


Figure 6.5: Package Diagram for Digital Descent

ule that handles the communication for multiplayer functionality in Digital Descent. It includes components for establishing connections, , and managing player interactions over the network and synchronizing game states.

- **Game Logic:** Represents the module that implements the specific game logic and rules for Digital Descent. It includes components such as the exploration system and battle system as seen in Figure 6.1.

6.2 Technology

The technology stack used in the development of Digital Descent combines client-side and server-side technologies. This section presents an overview over the technologies selected for each component, outlining the reasons for these choices. The employment of these technologies seeks to align with the desired architectural goals given the project's time constraints.

6.2.1 Client

React

The user interface (UI) is an essential part in any game development as it enables effective communication between the game and the player. React, a popular JavaScript library, quickly gained the attention as a viable technology for building the UI of Digital Descent due to a combination of factors such as the author's familiarity with the library and time constraints associated with game development projects. React¹ offers a component-based approach, enabling modular and reusable UI elements. Its virtual DOM (Document Object Model) efficiently updates and renders the UI, enhancing performance and responsiveness. For the client-side of the application, the authors believed that React fitted right in for Digital

¹<https://react.dev/>

Descent.

Phaser

When it comes to actually building a web-based game, there are several tools and frameworks available to assist developers in creating games with greater ease and efficiency. One prominent type of tool are game engines, which provides developers with the necessary capabilities required to create and develop games. These engines offer a wide range of functionalities that streamline the game development process, and includes functions such as input processing, physics, collision detection, and sprite animation.

Phaser², a powerful HTML5 game engine, was used in *Digital Descent* as the game engine used for the game development. Several considerations influenced the choice of Phaser for *Digital Descent*. Firstly, Phaser is widely considered as one of the most popular libraries for web-based game development, indicating its effectiveness and reliability. Additionally, Phaser's extensive documentation provides detailed explanations, examples, and tutorials, making it quite easy for the developers to fully understand and utilize its features, ultimately saving time and effort during development. Performance was also a crucial factor in selecting Phaser as the game engine used in *Digital Descent*. The engine's optimized rendering capabilities and efficient handling of animations, event handling and collisions ensured smooth gameplay and a great development and user experience. Ultimately, Phaser proved to be an ideal choice as it provided all the necessary tools and support a developer need to create an enjoyable and captivating gaming experience.

Alternative Game Frameworks

In addition to Phaser, various alternative game frameworks were thoroughly evaluated during the development of *Digital Descent*. These alternatives included frameworks such as Pixi.js³, Kaboom⁴ and Kontra⁵, each offering unique features and capabilities. The evaluation of these frameworks involved generating sprite-rendering benchmarks on different JavaScript-based game and rendering engines that were maintained during the writing of this thesis, as well as comparing the development experience using them.

During the evaluation of the alternative game frameworks for the development of *Digital Descent*, Pixi.js initially stood out for its exceptional rendering performance. However, it was quickly down-prioritized due to its limited functionalities beyond sprite rendering. In contrast, Kontra showcased comprehensive tooling and a robust component library, offering necessary basic game requirements needed for creating a game, suitable for rapid game development. How-

²<https://phaser.io/>

³<https://pixijs.com/>

⁴<https://kaboomjs.com/>

⁵<https://straker.github.io/kontra/>

ever, it lacked the performance optimization comparable to Phaser, which also offered most of the same functionalities as Kontra. Additionally, Kaboom caught the author's attention for its simplicity and ease of use, as it targeted beginners and smaller-scale projects. However, its poor performance and slow execution made it nonviable for Digital Descent. During the evaluation process, several other libraries and frameworks were thoroughly assessed as well. However, after careful consideration, Phaser emerged as the most suitable framework, combining the rendering capabilities of Pixi.js with a comprehensive feature set, strong performance optimization, and extensive documentation. The evaluations on the rendering benchmark can be found at the following GitHub repository: <https://github.com/Shirajuki/js-game-rendering-benchmark> and the comparison test can be found at <https://github.com/Shirajuki/js-sprite-animation-test>.

6.2.2 Server

Express

Express⁶, a widely adopted web application framework for Node.js⁷, the runtime environment running the web server, were chosen as the foundation for the server-side implementation in Digital Descent. The selection of Express is based on its robustness and simplicity, making it an ideal choice for developers to efficiently build and maintain its components. Furthermore, Express benefits from a large and active community, providing extensive documentation, tutorials, and a wide range of third-party plugins. This ecosystem ensures ongoing support, accelerates development, and provides solutions to common challenges, making it a suitable framework for Digital Descent.

SocketIO

Along with Express, SocketIO⁸, a real-time engine for web applications, plays an important role in Digital Descent by enabling real-time communication and synchronization between the client and server. The decision to incorporate SocketIO is driven by its ability to facilitate bidirectional communication using the WebSocket protocol, aligning with the Publish-Subscribe pattern. SocketIO's intuitive API and the use of the WebSocket protocol ensured efficient and reliable communication channels, allowing actions and updates from one player to be easily reflected across all other connected clients. This makes SocketIO an ideal choice for creating multiplayer functionality and delivering real-time gameplay experiences, enhancing the overall gameplay dynamics and fostering a sense of collaboration. With its compatibility with Express and ease of integration, SocketIO was found to be well-suited for Digital Descent for creating an engaging and interconnected gaming experience.

⁶<https://expressjs.com/>

⁷<https://nodejs.org/>

⁸<https://socket.io/>

6.3 Development

Given that the main contribution of this work is a prototype of Digital Descent, a dedicated period of two months was set aside for its development. In this section, we provide an overview of the development methodology followed during the design of Digital Descent. We discuss the chosen methodology's key principles that facilitated the efficient development of the game. Furthermore, we touch upon the implementation details and challenges encountered throughout the development process.

6.3.1 Methodology

To address the learning objective set out when designing the game, a list of requirements had already been formulated and refined multiple times as presented in Table 2.2. The requirements, however, were still high-level and needed to be broken down into smaller, more detailed tasks for implementation. As a result, the game was created in an agile manner, allowing for incremental refinement and evaluation of whether the game still meets the learning objectives. Given the project's time constraints, the authors adopted a lean methodology within the agile framework to ensure efficient development and timely delivery of Digital Descent. The lean approach emphasizes minimizing time waste and focusing on value creation by continuously iterating and improving the game. Despite the time constraints, the combination of agile and lean methodologies proved invaluable in ensuring the successful realization of the functioning prototype within the project's time frame.

6.3.2 Difficulties encountered

During the development of Digital Descent, several challenges were encountered that required careful consideration and adaptation. One notable difficulty arose from network problems and the initial decision to use UDP (WebRTC) for bidirectional communication over TCP (WebSocket). The authors had believed that UDP would offer faster communication, but it was soon discovered that UDP's lack of reliability posed significant issues. Packet loss and out-of-order delivery negatively affected the game's synchronization and multiplayer experience during the first usability evaluation. As a result, the decision was swiftly changed to use TCP (WebSocket) for its reliable and ordered data transmission instead, ensuring a stable and consistent gameplay experience for all player clients.

Another challenge faced during the development process was scope creep. Despite meticulous planning and refining of requirements, unforeseen complexities and time constraints prevented the team from implementing all the initially envisioned features and game mechanics. This necessitated prioritization and decision-making to ensure that essential components were completed within the given time frame. The authors focused on delivering a polished and functional core experience while acknowledging that certain planned features would need to be de-

ferred to a future work. The authors' ability to recognize and address the issues at hand promptly and adapt to the situation contributed to ensure that the game Digital Descent delivered a solid foundation for further expansion and improvement in the future.

Chapter 7

First Prototype and Evaluation

This chapter presents the first prototype testing of Digital Descent. It starts by describing the purpose of the prototype testing in the first section, providing a clear rationale for the approach of the user test. The following section will detail the testing procedures to ensure the understanding of methods used. The rest of the chapter will present the results received from the testing and evaluation. Finally, a discussion will take place, examining the implications of these results on the prototype's overall design and performance.

7.1 Purpose

The purpose of the initial prototype evaluation is to assess the usability and overall user experience within the game. The testing seeks to ensure that the players can navigate and understand the mechanics and objectives in the game. In addition to evaluating if the game is playable, this user test is also crucial to uncover any issues, bugs and glitches that might impact the game's performance, such as system crashes, unexpected responses, memory leak and network latency. The latter is especially important since the game is online and it can affect the performance and stability of the game in large degree. This test also serves as a pilot test to rule out testing procedures error and prepare for the upcoming main and expert evaluation.

Given that the game revolves around teaching the agile mindset, it is important that the game's mechanics accurately and effectively represents itself. This usability test, aim to identify whether players can intuitively understand the game's intent and apply the agile concepts in the game environment as well. This hands-on experience will allow the players to provide feedback on their perception of the game and its complexity. This feedback will be important to refine the game, ensuring its educational value in cultivating the agile mindset.

7.2 Participants

The participants for this prototype test were three students from NTNU. Three of them pursuing studies related to IT and computer science. These individuals covers the primary target group for the game, which is those with minimal experience in Agile methodologies. The participant selection was intentional, as they typically possesses some exposure to Agile concepts, allowing for a realistic evaluation in cultivating an Agile mindset in novices.

It's worth noting that another key segment of the target audience for this game includes professionals with little Agile experience. The absence of professionals in the testing phase may limit the full range of feedback. As professionals could potentially have different perspectives and expectations based on their work experience and insights. Future iterations of prototype testing should therefore try to include professionals to ensure a more complete evaluation of Digital Descent.

7.3 Process

Before conducting the prototype evaluation, a structured plan was made. It was decided that the evaluation would first consist of a usability test, followed by a focus group discussion. The evaluation was held in person, and participants were requested to allocate one hour and bring their own computer for the test, receiving the information on the structure of the process in advance.

Subsequently, a brief introduction to the master's project and the purpose of the usability test was provided. During the evaluation, data was collected through taking notes of the observation made during the usability test and the focus group discussion. Given that there were no voice and video recordings of the process, a NSD (Norwegian Centre for Research Data) application was deemed unnecessary.

7.3.1 Usability test

The usability test was designed and conducted following the guidelines of Preece et al. (Preece et al., 2019). During the game play the players were asked to complete a series of tasks, each task given sequentially upon completion of the previous one. The players were told to think out loud to allow the facilitators to get insight of what they were thinking. The tasks are made so the players are able to go through the first iteration of the game, ensuring they are exposed to all of the game's essential elements.

The tasks included in the usability test are as follows:

1. Start a game session
2. Complete the tutorial phase
3. Complete a whole game loop and iteration

At this stage of development, the game allows up to four players simultaneously. A virtual private server (VPS) could not be set up within the allocated

time frame, the gameplay was done over a local network and proxied through a third-party proxy-tunnel instead.

7.3.2 Group interview

Following the usability test, a group interview was conducted on the participants. Group interview would allow the questions asked to be answered individually but also allow open discussions around the topics. The discussion were facilitated by the authors, who encouraged the participants to freely express their thoughts and views on the game.

The group interview was structured around a set of questions designed to gather feedback on various aspects of the game. The questions were as follows:

1. "Could you provide your feedback on the usability of the game?" - This question was asked to get the first feedback that came on the participants mind and would allow a discussion to form from there.
2. "How would you rate your overall satisfaction with the game?" - This question aimed to understand the participants' general sentiments towards the game.
3. "Would you consider the game entertaining?" - This question aimed to assess the game's success in engaging and holding the interest of the players.
4. "How would you rate the difficulty level of the game?" - Understanding the game's perceived difficulty level would provide insights into whether the game is challenging enough for the players.
5. "What are your thoughts on the quality of the game's graphics and art?" - This question was asked to evaluate the game's audio and visual appeal.
6. "Could you suggest any improvements or features you would like to see in the game?" - This open-ended question was designed to gather constructive feedback and creative ideas for enhancing the game's design and functionality.

Through these questions, the group interview aimed to gather a detailed feedback on the game's usability.

7.4 Results

This section describes the results obtained through observations and group interview.

7.4.1 Observations

During the usability test, many usability issues were observed, ranging from minor to major ones. The players were able to create a lobby without significant issues. However, a minor problem arose when there were created two lobbies at the same

time. One of the player did not know how they could leave their current lobby in order to join the other lobby created.

Throughout the tutorial phase, it was noted that the players understood that the dialogues were not synchronized, where they were required to wait for each other to finish reading and clicking "next" on their own set of dialogues before proceeding. The players' ability to see each other's cursors during the dialogues also seemed to cause confusion with the synchronization problem and might not be appropriate to have there.

In the office room, where the players met the customer, they experienced difficulty finding the meeting room, despite there being only two rooms in the office. The specific positions of the objectives were not clear, making it difficult for the players to know where to stand to interact with it. Additionally, players were unaware that they needed to stand on an objective together to activate or interact with it. Furthermore, during role selection in the office room, it was not apparent to the players that they could select the same roles.

While going through the dialogues and tutorial, players appeared to be overwhelmed and bored by the amount of text and information given to the players in the dialogues. Some players seemed to skim through the dialogues rather than reading them thoroughly. Frustration was expressed over the amount of reading needed in the Dialogues. Text chat in the Digital World was also judged difficult to read due to insufficient background contrast.

The most significant issues were related to the battle system, where players attempted to battle bugs. The ability icons failed to display correctly, instead showing only a blank icon. Another concern was the excessive number of bugs to defeat, which made the task time consuming. This gameplay issue will need to be addressed by adjusting the damage dealt and the bugs' health (HP) to make it more balanced. A major memory leak occurred during the battle, causing the game to slow down as time went on. Upon investigation, the memory leak was found to be related to a full UDP queue, as observed when participants were requested to open their browser's console logs for debugging during the test. The players were also unsure whose turn it was due to a lack of indications. Moreover, upon completing the battle process, the players were expected to be teleported back to the Explore scene, but this did not happen due to the UDP queues being full.

7.4.2 Feedback

The participants expressed that the amount of usability issues made the game experience worse than it could have been. Always having to focus on understanding the problems relating to usability issues and finding a solution to them made it so that less time was spent on focusing on actually playing the essential parts of the game.

The participants had mixed reviews when asked about the overall satisfaction of the game. The participants liked the way the different game mechanics and the concept was combined to make this game engaging. They were generally pos-

itive to the multiplayer and collaboration aspect of the game. They thought the role selection was nice as they could stop and discuss and learn about the roles. The same thing with the task board, where the task board allowed the players to collaboratively drag and drop the tasks together, doing so promotes the collaboration effort in the team. However, they all acknowledged that their satisfaction was greatly impacted by the number of usability issues they encountered. They believed that with some fine-tuning and fixing these usability issues, the game has the potential to be much more enjoyable.

When asked if the game was entertaining enough, the participants generally agreed that the game held their interest. The first few iterations in the game was fun and they liked the battle sequence. However, they also mentioned that it was too repetitive to only have objectives related to battling the bugs. After a few battles with the bugs they thought it was boring and couldn't imagine to finishing multiple iterations with only battling the same type of enemy. They suggested to add other monsters to battle such as viruses and malware, making it a bit more engaging with the variation.

Regarding the difficulty level, the participants felt that the game was not challenging enough. The participant meant the bugs did little damage on the player. It was said that it was easy because they didn't have to think about which abilities to use, only using the same ability would kill the bugs eventually. However, the damage dealt to the bugs and the health needed to be more balanced as the killing of bugs took a bit too much time. The players always had over 90% of their health left during the whole gameplay, indicating that they knew that they didn't need to worry about the health at all. This balancing issue was also inherent when battling against the customer.

The participants were very positive to the game's graphics and art. They liked the simple black and white art of the game as it was minimalistic making it less of a distraction when the focus of the game is to learn. The participants also liked the movement system which was smooth as they walked around the game world of Digital Descent.

Finally, when asked to suggest improvements or additional features for the game, the participants provided feedback on the many usability issues that were observed during the test. This confirms the observations made during the gameplay. The feedback included improving the dialogue synchronization in the tutorial, clarifying the positions of objectives, and improving the battle system. They also expressed interest in seeing more variety of tasks and objectives.

7.5 Discussion

This discussion will describe the key findings from both the usability test and the group interview.

As stated earlier, the purpose of the initial prototype test is to assess the usability of the game. Therefore, the focus was not set on the results if the game achieves an effective learning objective or not. This is planned to be evaluated with game

design and Agile experts. Given the small sample size, the importance of qualitative data is weighted more than quantitative data in this evaluation. Lastly, this discussion will outline the implications of the results for the ongoing development of Digital Descent, and provide a change log that should be done before the next evaluations.

7.5.1 Usability

The usability test and group interview revealed some important insights of the game's usability. Participants experienced significant issues, particularly with the game's user interface and the battle sequences. These challenges negatively impacted both the overall satisfaction and usability of the game. For example, when a battle ends, the game simply freezes, creating confusion and interrupting the gameplay flow.

The International Standard Organization (ISO) defines usability of a product as the extent so that user can use the product to achieve their goals with effectiveness, efficiency and satisfaction. Satisfaction is one of the five quality attributes of usability. It indicates that user is pleasant to use the system or not (Nielsen, 2003). Therefore, it becomes evident that usability issues in the game have affected player satisfaction.

All of the participants pursued IT-related studies, and therefore is expected that they have a higher technical competencies and should play the game as intended. However, they found it difficult to figure out how to interact with the objectives to enable or activate them, clearly indicating contrast with Nielsen's Usability Heuristics - Visibility of System Status. This heuristic states that a system should always inform the users what's going on using proper time feedback. User should know what's going on and what his next task is. This difficulty shows that the game's shortcomings, which affects even technically competent players, this is a strong argument for improving the user interface.

The implications shows that the usability issues identified need to be addressed to improve player satisfaction and ensure that the educational potential of Digital Descent is not undermined by a frustrating gameplay.

7.5.2 Difficulty

Regarding the difficulty of the game, the findings showed that the game was perceived too easy. The bugs was easy to kill and the damage done on the player from the bugs were too low. The participants noted a lack of progressive difficulty, as the perceived challenge presented by the bugs remained constant throughout the game. The only encounter perceived as more challenging was the battle with the customer, but even this was effortlessly manageable for the participants. This issue contradicts one of the instructional design principles proposed in the game design which is the Regime of Competence Principle. This principle states that the game has to progressively increases in difficulty as players advance through levels, ensuring that they are consistently challenged but not overwhelmed.

The identified issues related to difficulty appear to be primarily associated with game balance, which needs adjustment. A better balance adjustment, where the bugs become incrementally harder, and the damage done on player increases in line with game progression should be made. This balance will ensure that the game remains challenging, pushing players to develop their skills.

7.5.3 Changes

To organize the input and changes proposed throughout the evaluation, a changelog was created. The changelog includes a priority level that describes which modifications should be made before the next evaluations. The changelog also includes some other minor usability issues not mentioned that were found during the further implementation of the game. The changelog is presented in Table 7.1.

ID	Description	Importance
1	Add leave button to the lobby room	medium
2	Fix player name bug not displaying	medium
3	Make the dialogue synced for all players	high
4	Make a clear indicator of where the objective is	high
5	Make it clear that the players can pick the same role	medium
6	Shorten the dialogue and make the tutorial go faster	medium
7	Fix minor button issues	low
8	Make text chat box more less transparent	low
9	Fix issue where icons and images doesn't load	high
10	Fix minor button issues	low
11	Implement a button so the players can leave battle	low
12	Fix memory leak during battle	high
13	Fix issue where player can not see the roles of everyone	medium
14	Balance the game to make it more difficult	high
15	Add indicator to know which player's turn in the battle	high

Table 7.1: Changelog after the first usability evaluation

Chapter 8

Expert evaluation

This chapter describes a thorough evaluation of Digital Descent done by expert individuals. In this stage, most of the game's usability issues proposed in the last evaluation have been addressed and fixed. This chapter begins by presenting the purpose of the expert evaluation and information about the selection of expert participants. The chapter further elaborates on the detailed evaluation process, which consists of an expert user test and a follow-up interview. This approach is designed to gather an in-depth understanding of the experts' experiences and perceptions of the game.

Finally, the findings from the user test and interview will be presented and discussed at the end of the chapter. Overall, this chapter highlights the insights of experts which are knowledgeable about Agile methodology and game design. Their expertise will help to identify improvements to the game's learning effectiveness and user experience.

8.1 Purpose

The primary purpose of the expert evaluation was to gain valuable feedback on Digital Descent from professionals in relevant fields. This evaluation aims to contribute to the understanding of **RQ1.3**: *Can we overcome the challenges associated with Agile learning by creating a game for Agile Software Development that incorporates motivating gamification and game elements?*

This evaluation is not just a critique of the current state of the game but an important step in identifying the strengths and weaknesses of the game's learning and engagement mechanics. While the game currently is a playable prototype rather than a finished product, the feedback gathered will be crucial for the upcoming main evaluation. Although usability is not the focus in this evaluation, any feedback or suggestions received will be noted and taken into account.

8.2 Participants

The expert evaluation involved three participants working in the IT industry. Two participants had substantial experience as IT consultants, with additional experience in self-developed games. The first participant had five years of experience as an IT consultant and some experience with self-developed games, while the second participant had four years of experience as an IT consultant along with one year of game development experience. The third participant held the role of IT manager and had good expertise in Agile methodologies.

The selection of participants aimed to have a diverse backgrounds and knowledge. The first two participants would serve as game design experts, bringing their experience in game development to provide valuable insights about the game mechanics and game motivation, while the third participant, an Agile expert, would bring expertise in evaluating the game's alignment with Agile principles and learning objectives.

8.3 Process

The process in this evaluation will be similar to the one done for the first user testing, but this time, tailored to the experts. Three individually evaluations were conducted with the experts, and began with a user test, followed by a semi-structured interview. The evaluation was held digitally using Microsoft Teams¹, where the participants were asked to allocate one hour for the evaluation. Detailed information about the entire evaluation process was provided to the participants prior to the test.

After a brief introduction to the master's project and its purpose of research, the user test and interview started. Observations during the user test and the interview were noted to gain insights. As there were no voice and video recordings, the need for an NSD (Norwegian Centre for Research Data) application was unnecessary.

8.3.1 User Tests

The user test followed a structured approach similar to a typical usability test as done in the last evaluation. This time the game was deployed to a virtual private server (VPS) which meant that the game were played online as intended and not done through a local network. The game were updated to accommodated up to eight players simultaneously. However, only two players will be playing simultaneously during this user test. One of the authors acted as the second player to simulate the game being multiplayer, joining the game as a neutral observer while the participant led the the actions and decisions in the game.

Participants were asked to play the game and complete a series of tasks designed to assess the usability and the educational value in different parts of the

¹<https://teams.com/>

game. The tasks were given sequentially, with each task being presented after the completion of the previous one. Participants were encouraged to express their thoughts and provide feedback as they went through the game, allowing facilitators to gain insights into their decision-making processes.

The tasks assigned to participants during the user test included the important elements of the game and aimed to provide a thorough gameplay experience. The tasks were adjusted significantly after the initial user testing to make them more clear, as they were judged a bit too unclear. More tasks were also added so that the participant may explore more of the game's features since we wanted to acquire a better understanding of the full game cycle. The tasks were:

1. Start a game session
2. Arrive at the Digital World
3. Complete the 3 objectives in the Digital World
4. Reach day 2 of the iteration
5. Reach day 6 of the iteration

8.3.2 Interviews

An interview was conducted immediately after the gameplay session. The interview was conducted in a semi-structured manner, providing more flexibility to the participant to dive deeper into different topics. A set of predefined questions were prepared prior to the interview to ensure nothing was forgotten. The questions covered many aspects of the game, including its usability, learning elements, engagement elements, and potential areas for improvement. These questions can be found below and also within the interview guidelines, each accompanied by its underlying rationale. The interview guidelines can be viewed in Appendix A. During the interviews, participants were asked to provide detailed feedback and express their opinion openly. The participants were encouraged to be as critical to the game as they wanted to.

General

1. What is your first impression of the game?
2. What did you like the most about the game and why?
3. What did you like the least about the game and why?
4. Who do you think the game is suitable for?
 - a. Is the game suitable for new graduates in terms of content and the amount of Agile background information provided?
5. Did you encounter any challenges with the game?

Learning outcome

1. Can you see the connection between Agile and the game elements used to teach Agile?

- a. Can you provide examples of the game elements that are related to Agile?
2. Are there any game elements you feel are missing in terms of learning the Agile mindset?
3. What do you feel you will learn the most from the game?

Game-related and Engagement

1. How entertaining was the game?
 - a. Which game elements did you find fun?
2. How challenging was the game for the target audience?
3. Were the help and information texts provided during the game phases sufficient?
4. Does the game effectively promote collaboration through the game elements used?
5. Did the game facilitate communication and discussion between players?
 - a. Which parts of the game do you feel facilitated the most discussion among players?
6. What are your thoughts on the game's game loop? Is it too repetitive considering the iterative tasks?
7. What are your thoughts on the implementation of the task board in the game?
8. Do you have any other suggestions for improvements or new features we could add?

8.4 Results

This section describes the results obtained through observations and interview. The subsection for the game design experts and Agile experts will summarize all the observations and answers for all the participants during the evaluation.

8.4.1 Participant 1 (Game design expert)

The interview held with the first participant was shorter than planned due to the technical issues during gameplay. However, valuable feedback were provided regardless.

General impression of the game

When asked about the first impression of the game, the participant expressed that the game was fun to play and they understood that they are expected to learn

something from the game. They particularly enjoyed using the task board, appreciating the interactive and user-friendly drag-and-drop functionality. The participant mentioned that the coordination and task management with the team members became seamless due to the visibility of other player's mouse cursors. However, in terms of things that they disliked, they mentioned that the background music and sound effects were a bit too loud. They found it distracting and attempted to adjust the sound settings to lower the volume but could not due to not having a sound settings implemented in the game. Additionally, the participant expressed their frustration with the amount of text in the dialogue, feeling that it was excessive and time-consuming to read.

During the gameplay as observed, the participant did not appear to encounter any significant difficulties. However, during the interview, they mentioned that it took some time for them to understand what the abilities when battling the bugs did. As a suggestion for improvement, the participant recommended simplifying and standardizing the symbols for different abilities, regardless of the player's role. For instance, using a sword symbol to represent attack, which is widely recognized. When asked about the ease of understanding the game mechanics, the participant mentioned that it became clear after a certain point of playing. However, they were unsure about the purpose of some of the stats displayed to the player when they levelled up, and questioned its significance in the game.

The participant's feedback highlighted the importance of addressing problems related to sound settings and reducing text overload in the dialogue. Additionally, simplifying and standardizing symbols for player roles and abilities, and providing a clearer explanations of the game mechanics, including the purpose of certain stats, could improve the overall gameplay and learning experience.

8.4.2 Participant 2 (Game design expert)

Small changes were performed following the user test with the first participant due to the varying times in the evaluations of the different experts. These were mostly some minor usability issues and sound-related adjustments.

General impression of the game

When asked about their first impression of the game, the participant expressed a couple of concerns. The participant highlighted the excessive amount of text in the dialogue, which made it challenging to remember and makes it boring in the beginning. The repetitiveness of fighting bugs and viruses or doing quizzes also contributed to the perception of a monotone gameplay. Additionally, the participants felt that the battles were slow and lacked variation, leading to a lack of motivation to complete the tasks on the task board. Also, he expressed that the battle was too easy, making it effortless to play, affecting the motivation of the game. The participant suggested introducing skill unlocks at different levels or stages to maintain player interest and a sense of progression.

Regarding the aspects they liked the most about the game, the participant appreciated the multiplayer feature. However, it was said that additional players did not significantly enhance the gameplay experience, since the participant meant that the game did not effectively promote cooperation among players. At this state of the game, it was said that the additional of players only added to a longer game time without giving any more value.

On the other hand, the participant expressed their least favorite aspects of the game. They mentioned the excessive pre-explained text in the dialogues, suggesting that on-time explanations would be more effective and engaging. The game's fast-paced and repetitive nature, coupled with a lack of content, further contributed to their dissatisfaction.

When considering the target audience, the participants believed that the game would be suitable for individuals who have not previously encountered Agile concepts. However, they emphasized the need for the game to provide more learning elements to support players in solving the quizzes. The participant meant that the quizzes required some knowledge about Agile beforehand which is not taught during the gameplay. Regarding the game's suitability for new graduates, the participant indicated that university courses typically cover a significant amount of Agile concepts, making the game less informative for this particular group. However, they saw potential in the game as an introductory tool for a small part of a course. The participant also suggested incorporating actions in the dialogue system to make it more interactive and engaging.

Game-related and engagement

In terms of the game's difficulty level, the participant noted that while the mechanics were relatively easy to grasp and use, there was a significant disparity between the game elements and the intended learning outcomes. The participant felt that the game mechanics did not effectively connect to Agile concepts, making it challenging to acknowledge the learning of Agile principles. For example, the battle system for combating bugs and viruses. Is the battle system a clear representation of the work part of Agile? This raised the question of whether these mechanics could be applied to the Agile processes represented in the game in real-life circumstances or not. The participant suggested that additional efforts could be made to bridge the gap between the game mechanics and the desired learning objectives, ensuring a better integration of Agile concepts. Regarding collaboration, the participant expressed the need for more cooperative elements in the game. While the multiplayer aspect was appreciated, it was felt that the game did not fully capitalize on promoting collaboration among players. The participant suggested to include interactive puzzles or tasks that require teamwork and problem-solving, promoting engagement and cooperation. Such additions would provide players with opportunities to work together, communicate effectively, and collectively strategize to solve challenges in the game.

In terms of communication and discussion among players, the participant

noted that the battles against bugs and viruses did not effectively encourage communication or cooperation. The simplicity of the mechanics allowed players to rely on basic attacks without much strategic thinking or interaction with other players. However, the participant highlighted the quiz section as an area where communication and discussion were promoted the most. The quiz segment stimulated discussions among players as they exchanged ideas, shared knowledge, and together chose the correct answer. Expanding on this concept, the participant suggested incorporating more interactive elements or more diverse challenges that facilitate communication and encourage players to engage in meaningful discussions throughout the game.

When asked about the task board and if the task board was well implemented, the participant expressed that this is an area that required improvement as well. The participant found the management of the energy element and the selection of tasks somewhat confusing. The participant suggested to include on-demand guides or pop-ups to provide clarity on the energy element and guide players in optimizing their task selection. Additionally, the participant emphasized the need for more task variation within the game. The repetitiveness of battling bugs and viruses, or completing quizzes, contributed to a decrease in overall game experience.

When asked if the participant had any suggestions for improvements and new features, the participant highlighted the importance of adding more content and variation to the game. This would involve incorporating additional gameplay elements, game modes and challenges that align with Agile principles. The participant specifically recommended the inclusion of cooperative puzzles that require players to collaborate, combine their knowledge, and work together to solve a problem. For example, one player has to do a subtask while another has to do another subtask, where they altogether get some knowledge from their respective subtasks and have to combine it to solve the main task. These puzzles would promote teamwork, critical thinking, and problem-solving skills, enhancing the educational value of the game. Furthermore, the participant expressed a desire for more opportunities for discussion within the game, such as the option to hold meetings during the game, allowing players to engage in dialogue, share insights, and learn from one another.

8.4.3 Participant 3 (Agile expert)

The evaluation for the third participant had a different focus since they served as the agile expert for this user test. As a result, the semi-structured interview was somewhat altered to focus on the game's learning outcomes.

General impression of the game

When asked about the participants' first impression of the game, the participant thought that the initial dialogue presented an overwhelming amount of information. This led to difficulties in remembering and retaining the information through-

out the game. The participants suggested that it would have been more effective to distribute the information gradually throughout the gameplay, avoiding information overload at the beginning. Additionally, there was confusion surrounding the game element regarding the energy points in the task board, indicating a need for better clarification and explanation.

When asked about their favorite aspect of the game, the participant agreed that the quiz and the task board component was the most enjoyable. It provided a sense of fun and engagement, while providing a significant educational value within the game. On the other side, the participant expressed a dislike for the difficulty in understanding their role-specific abilities during battles. They found it confusing and challenging to grasp the purpose and functionality of the abilities. It wasn't until the facilitator pointed out that there was a help button with a question mark under the user test that they realized the explanation of the players' abilities was available. This button may have been placed differently, according to feedback.

In terms of the game's target audience, the participants believed that the game is suitable for individuals with some prior knowledge of Agile concepts. Certain terms and elements within the game, such as iterations, backlog and daily meetings, were not adequately explained, potentially leaving new players unfamiliar with Agile feeling somewhat lost.

As for the challenges encountered during gameplay, the participants encountering some bugs that wasn't discovered prior to the test during the gameplay. One notable issue involved a malfunctioning question during the quiz, rendering it impossible to select an answer and causing the screen to become unresponsive.

Learning outcome

When asked about the connection between Agile and the game elements used to teach Agile, the participants mentioned the importance of breaking down tasks into smaller, manageable components. They recognized this as a fundamental Agile practice that was effectively incorporated into the game. Additionally, the concept of iteration, where progress is made incrementally over time, was identified as another significant aspect that reflected Agile principles.

Furthermore, the participants acknowledged that the game effectively promoted collaboration, particularly during battles where players had to coordinate their abilities and roles. It was suggested that it would be more fun and that the game should be played with more than two players for a better collaboration experience. When it came to facilitating communication and discussion between players, the participant felt that choosing tasks and engaging in battles provided the most opportunities for discussion and interaction.

In terms of missing game elements for learning the Agile mindset, the participants expressed a desire for an open-world environment. They believed that having a cohesive, interconnected world rather than separate instances, such as the digital world and codebase, would enhance the learning experience. It was

also noted that the randomized feature of the exploration scenario took away some of the players' decisions. Instead of being randomized, the option to battle, rest, or quiz should be available at all times.

When asked about the most significant learning outcome from the game, the participants emphasized the importance of task prioritization. They mentioned that the game encouraged them to select and complete the right tasks for maximizing the progression, a crucial aspect of Agile project management. Additionally, the participants expressed a desire for more comprehensive feedback during the quiz component. They suggested that explaining the correct answers, rather than simply indicating whether an answer was right or wrong, would enhance the learning experience and facilitate a deeper understanding of the Agile concepts.

In terms of suggestions for improvement and new features, the participants recommended enhancing the roles within the game to have more value and impact. They suggested incorporating additional roles, such as an Interaction designer, to make the team more interdisciplinary and reflective of a product team rather than solely a development team. These findings underscore the positive aspects of game mechanics and collaboration in the game, while also providing valuable suggestions for further enhancing the entertainment value, motivation, and role dynamics.

8.5 Discussion and Changes

8.5.1 Usability

The usability of Digital Descent is generally good. But the participants had still experienced a few usability issues. The most prominent usability issue which was mentioned by the experts were that the initial dialogue contained an overwhelming amount of information, leading to difficulties in remembering and retaining it throughout the game. Additionally, there was confusion surrounding the energy element in the task board, indicating a need for better clarification and explanation. Some bugs were also found during the testing which hindered the participants to continue on the game. These usability issues can hinder the learning process and should be addressed to ensure a smoother gameplay experience for new players.

8.5.2 Learning element

The game aimed to introduce Agile concepts to a target audience of fresh graduates or professionals with no prior knowledge in Agile. When asked if the participants could identify the learning aspects of the game, the most prominent aspect mentioned by all participants were learning to work iterative (**LO1**). Additionally the learning objective related to estimating workload and time (**LO4**) was also recognized by the participants through the way the task board was designed. The task board encouraged the participants to select and complete the tasks they had

decided on in order to maximize their earnings and progress with the game. The two other learning objective didn't seem to be promoted well enough in the game. As the participants expressed that game balancing was poor leading to no effort needed to collaborate in the team and having to take risks and think thoroughly in taking decisions.

Regarding learning the basic Agile concepts, the participants expressed a desire for more ways to learn the basic terms of Agile as well as the questions and answers introduced in the quiz. The mentioned examples were to include small lessons or popups during the gameplay, and making dialogues more interactive. Additionally, One of the participant mentioned that the game should provide comprehensive feedback during the quiz component, suggesting that explaining the correct answers would enhance the learning experience and facilitate a deeper understanding of Agile concepts.

8.5.3 Engagement elements

The participants found certain aspects of the game to be engaging and entertaining. Choosing tasks, receiving experience points, and earning credits added a sense of engagement and reward. However, there were concerns about the game's difficulty and lack of variation and content, especially during battles, which were perceived as slow and repetitive. The participants suggested optimizing the battles for faster gameplay to maintain engagement and to find some way to add more content like additional challenges and game modes. The multiplayer feature, although appreciated, did not significantly enhance the gameplay experience as much as intended, since the game did not effectively promote collaboration among players. The participants recommended incorporating interactive puzzles or tasks that require teamwork and problem-solving to encourage cooperation and engagement. The quiz section was highlighted as an area that facilitated communication and discussion among players. The participants also emphasized the importance of more motivation elements in the game, such as player customization, and suggested enhancing the roles within the game to make the team more interdisciplinary and reflective of a product team. These suggestions aim to improve the overall entertainment value, motivation, and role dynamics within the game.

8.5.4 Proposed changes

Considering the time constraint for the thesis, it was not feasible to continue the development on Digital Descent at the current time of finished the evaluation. However, to ensure that the valuable feedback and proposed changes from the evaluation process were captured, a changelog was compiled and presented in Table 8.1. Implementing fixes for these changes is set for a future work.

ID	Description
1	Fix the balancing of the customers
1	Fix the bug where the last boss fight against the customer doesn't initiate
2	Fix cursor of the players to correctly sync
5	Remove dialogues explaining unnecessary information
6	Shorten the dialogue and make the tutorial interactive
8	Allow for the use of keybindings for focusing on the text chat box
9	Update ability icons and images to better represent the attack
10	Fix minor navigation issues
11	Implement a button so the players can view their stats at all times
12	Figure out a fix to better the performance on Safari browsers
13	Fix issue where player experience does not sync after battle
14	Further balance the game to make it more difficult
15	Add more variety in tasks
15	Add more variety monsters to battle

Table 8.1: Changelog after the expert evaluation

Chapter 9

Main evaluation

This chapter presents the main evaluation of the game Digital Descent, focusing on individuals with little to no knowledge about Agile. It is important to note that, due to time constraints, the identified issues from the expert evaluation were not addressed in this stage of the evaluation process. Despite the unresolved issues, the evaluation aimed to gather valuable insights regarding the effectiveness of Digital Descent as an educational tool for teaching Agile Software Development concepts to fresh graduates.

This chapter begins by outlining the purpose of the main evaluation and providing information about the selection of participants with limited familiarity with Agile. The chapter further presents on the evaluation process, which consists of gameplay test and a follow-up focus group interview. This approach is designed to gather further perceptions, preferences, and suggestions for improvement. Finally, the findings from the user test and group interview will be presented and discussed in the last sections.

9.1 Purpose

The purpose of the main evaluation was to conduct a comprehensive evaluation of the game. This evaluation will be done with a larger amount of participants and to fully evaluate the latest version of the game. The evaluation aims to assess the game's effectiveness in introducing Agile concepts to the target audience of fresh graduates or professionals with little to no knowledge of Agile. The focus will be mainly on the learning elements and the engagement elements.

9.2 Participants

The main evaluation included five participants. All the participants were students from NTNU. Four of the students pursued computer science while the last student pursued civil and environmental engineering with specialization in construction and ICT.

The participants were selected based on their prior knowledge and which year they are on their study. The computer science students were either on their first year or their second year of study. One of them had little experience and knowledge about Agile, while the other two students had recently finished an introduction course to Agile, and worked part-time in an Agile team. The majority of the students had some familiarity with Agile and its fundamental concepts, which was ideal for the target group.

9.3 Process

The process in this evaluation will be similar to the one done for the first usability testing. The evaluation began with a user test where the participants play the game of Digital Descent, and a focus group interview will be conducted after the gameplay. Detailed information about the evaluation process was provided to the participants prior to the evaluation.

After an introduction to the master's project and its purpose, the user test and interview started. Observations during the gameplay and the interview were noted to gain insights. Similar to the evaluations prior this the need for an NSD (Norwegian Centre for Research Data) application was deemed unnecessary as there were no voice and video recordings taken.

9.3.1 User Tests

Since the gameplay test was conducted following a methodology similar to the previous evaluations, not much was changed in the user test process. In this test, all five participants formed a team, seated together around a table in-person, each using their own personal computer to play the game.

The participants were instructed to complete a series of predetermined tasks, which were identical to those used in the expert evaluation. These tasks were presented to the participants sequentially, with each task being introduced after the completion of the previous one. Throughout the gameplay session, participants were encouraged to express their thoughts and provide feedback, allowing the facilitators to gain insights into their decision-making processes and overall experiences.

The tasks assigned to participants aimed to evaluate various aspects of the game, including its usability, learning outcomes, and engagement elements. Since the main evaluation took place shortly after the expert evaluation, the tasks assigned to the participants were largely similar. The positive with this decision is that it ensured consistency and enabled a direct comparison of the results between the two evaluation phases.

9.3.2 Focus Group Interview

Following the gameplay testing, a focus group interview was conducted on the participants. The focus group interview conducted in this evaluation allows the questions asked to be answered individually but also opened up for discussions around the topics. The dialogues were facilitated by the authors, who encouraged the participants to freely express their thoughts and views on the game. Due to the time constraint and the similarity in focus between the expert evaluation and the main evaluation, the questions posed to the participants in the main evaluation were also similar to those used in the expert evaluation. The questions can be found in 1 or in the interview guide viewed in Appendix A.

9.4 Results

General impression of the game

The participants expressed positive feedback regarding the game's graphics and overall visual style being "cool", which created an appealing first impression. They appreciated the interactive mouse pointer feature during the task board, as it provided an engaging and user-friendly interface for managing tasks collaboratively. The inclusion of descriptive tasks was also well-received, as it offered clear guidance and instructions for completing objectives.

When asked about what the participants liked about the game, the participants expressed that they enjoyed the chat feature in the game, which allowed them to have fun and engage in random conversations with other players. Additionally, the participants found the movement in the game to be fun and well implemented. However, participants also discussed aspects of the game that they liked the least. The repetitive nature of the gameplay, often referred to as "the grind", was mentioned as a drawback, as it became less engaging over time. Some participants also felt that there was a lot of waiting for other players, which led to a slow-paced gameplay experience. To address these issues, participants suggested incorporating more variation within the game to keep it engaging and prevent repetitiveness.

When discussing the game's target audience, participants highlighted the importance of having prior knowledge of Agile concepts to fully understand and get the most out of the game.

In terms of the game's suitability for students and new graduates, participants expressed that prior knowledge of Agile was beneficial for fully appreciating the game's content. Those who had previous experience with Agile, such as having taken a course, found the game to be well-aligned with their knowledge level and considered it suitable. However, the participants suggested that the game could benefit from improving the presentation of Agile concepts, as some participants found the current dialogue-based approach to be lacking, for example in explaining terminology in Agile. Explaining the Agile concepts in a more clear manner could enhance the overall learning experience for players with limited Agile knowledge.

Challenges encountered by the participants during gameplay were also discussed. Participants mentioned a lack of overview of the different roles in the game, which made it difficult to identify team members and their responsibilities. They also found it challenging to notice when someone typed in the chat, as the chat box at times were not noticeable enough. To improve player identification in the game, participants suggested the inclusion of player customization options, allowing individuals to personalize their in-game avatars. This will allow the players to recognize each other when playing instead of all the avatar being identical.

Learning outcome

During the interview, participants discussed the learning outcomes they anticipated from playing the game, underlining the connection between Agile principles and the game elements designed to teach Agile concepts.

Participants recognized several game elements that aligned with Agile practices. They pointed out that the game's representation of weeks and days in iteration reflected the iterative nature of Agile development, where work is organized into time-based iterations. This aspect emphasized the importance of working in small, manageable increments and regularly evaluating progress. Another game element that participants identified to be related to Agile was the prioritization of tasks in the task board. They acknowledged that the game encouraged them to prioritize and select the most important tasks, which reflected the emphasis of delivering value early and frequently in Agile. This aspect helped participants develop decision-making skills and understand the significance of task prioritization in Agile project management.

Participants also mentioned the inclusion of customer meetings in the game is a relevant Agile element. They recognized the importance of close communication with the customer and the need to gather feedback for further development. By simulating customer meetings, the game highlighted the importance of involving customer in the development process as well as emphasizing the iterative nature of Agile, where constant evaluation and adaptation are essential. Additionally, participants noted that choosing roles in the team was another game element that reflected Agile practices. They recognized the interdisciplinary nature of Agile teams and the need for individuals with different expertise to work together effectively. By assigning roles within the game, participants experienced the importance of role allocation and collaboration in achieving project objectives.

Furthermore, it was expressed that the participants through the game, saw the importance of having every team member on the same page and the need to ensure that everyone in the team is aligned and working together towards a common goal. They mentioned that the game was made so that the team has to stay close together to interact with objectives, ensuring that everyone has to be focused on the same task and no one is left behind. Participants also meant that they learned how to prioritize tasks effectively, applying the concept of "min-max

prioritization" to maximize the rewards from the tasks such as experiences and work credit while balancing and estimating the time it takes to complete the task.

Game-related and engagement

When asked about the entertainment value of the game, participants thought the initial experience of the first two first days in the game to be fun. However, they expressed that the game became repetitive and less engaging after those two days. The team aspect of being able to freely navigate the game world together and the role-playing aspect were mentioned as elements that added enjoyment to the game.

Regarding the game's level of challenge, participants noted that the difficulty seemed to decrease as more players joined the game. They pointed out issues with balancing and player scaling, and that it was too easy to defeat the monsters and complete the tasks. Furthermore, the participants shared mixed feedback on the sufficiency of help and information texts provided during the game phases. While they all agreed that there was a lot of text to read, they found the content to be generally sufficient. The content gave a good introduction to Agile, but the participants meant some terminology could be explained in more detail.

When discussing the promotion of collaboration through the game elements implemented in the game, participants expressed that the poor balancing and player scaling negatively affected the need for cooperation among players. It was noted that the game could be improved in this aspect by addressing the balancing and scaling issues. This same problem were expressed in terms of facilitating communication and discussion between players, since the gameplay was at times a little bit too easy. Overall, the interview findings shed light on various aspects related to game-related elements and engagement.

9.5 Discussion

This section discusses the findings and implications of the study, focusing on the usability of the game, the learning objectives achieved, and the engagement elements experienced by the participants. Additionally, the a proposal for future work of the game and areas for improvement will be addressed.

9.5.1 Usability

The usability of Digital Descent were deemed to be good as indicated by the participants' many positive feedback. Due to the lack of updates on the game since the expert evaluation, it is not surprising that many of the usability issues identified in the expert evaluation persisted in the main evaluation. Participants encountered similar challenges and frustrations related to usability during their gameplay. The dialogue had still too much text, hindering participants to remember all the details. Additionally, there was confusion surrounding the energy element in the task

board as well, indicating a need for better clarification and explanation at certain areas.

9.5.2 Learning Objectives

Based on the feedback received from participants during the evaluation, it was evident that they were able to recognize several key learning aspects within the game that is related to the learning objectives of Digital Descent. The representation of weeks and days in Digital Descent aligned well with the iterative nature of Agile development, emphasizing the importance of working in small increments and regularly assessing progress. This alignment with the first learning objective, **LO1**, helped participants understand the significance of iterative approaches and the value of continuous evaluation.

Participants also acknowledged the task prioritization feature through the use of the task board, which contributed to the development of their decision-making skills. The ability to adapt to customer feedback further fostered an understanding of the importance of delivering value early as well as reinforced the learning value associated with **LO3**. By prioritizing tasks and incorporating customer feedback, players learned the significance of adjusting their approach and accommodating changing requirements.

Additionally, the mechanics promoting teamwork and collaboration, along with the inclusion of customer meetings, underscored the need for effective communication with both team members and customers. These aspects aligned well with **LO2**, emphasizing the importance of close collaboration and communication in Agile development.

However, it was noted that the learning objectives related to workload estimation and time management (**LO4**) were not strongly emphasized in the game. Participants expressed that the game's poor balancing and lack of challenge hindered their ability to make strategic decisions effectively, such as re-prioritizing tasks based on their workload and time constraints.

9.5.3 Engagement Elements

Regarding the game design principles discussed in section 4.3.4, it was found that the principle of "Identity" were somewhat implemented, as players control their own in-game avatars, allowing them to explore different roles and responsibilities within an Agile team. The participants expressed satisfaction in the way that they could chose to their roles, acknowledging the importance of roles in Agile. However, it was also expressed that this principle could be better implemented through a better way of indicating the different roles as the participants meant that it was hard to keep an overview of the other players' role. The incorporation of player customization options was also suggested.

The second principle being "Practice" were also deemed to be somewhat implemented as Digital Descent provided numerous opportunities for players to practice their Agile principles through doing tasks and going through the dialogues. The

results showed that the participants could practise Agile concepts when playing the game, but it was stated it quickly became boring because of the lack of content and variation through the task.

Finally, the third principle, "Regime of Competence," was partially implemented in the game as the game difficulty did somewhat gradually increase as players advanced through the gameplay. However, based on the evaluation results, it was evident that the game was still too easy and did not become progressively more challenging as intended. This was primarily due to game balancing issues that need to be addressed. The lack of increasing difficulty resulted in a decrease in engagement and made the game feel monotonous. Adjusting the game's difficulty curve to align with the team's level and progression is crucial to ensure that players are consistently challenged and remain engaged.

Despite the identified issues and areas for improvement, it is worth noting that the engagement elements of the game were generally perceived positively and aligned with their intended purpose. The other principles, although not explicitly mentioned, were considered to be fully implemented in the game. This includes principles such as "Active, Critical Learning", "Multiple Routes" and "Intuitive Knowledge". These principles contributed to creating an immersive and cohesive gameplay experience that effectively conveyed Agile concepts and promoted engagement and motivation.

9.5.4 Proposed changes and future work

One of the main issues identified during the evaluations of Digital Descent was the lack of content and variation within the game. To improve the content and variation in Digital Descent, several proposed changes can be implemented. Firstly, incorporating additional game modes or levels can introduce new and exciting challenges for players to overcome. These game modes can feature different scenarios or objectives, requiring players to apply Agile principles in diverse contexts. Adding more tasks and challenges will give players more opportunities to practice and it would help with the engagement.

Furthermore, introducing new types of tasks and puzzles can enhance the learning experience and provide a greater sense of accomplishment. These tasks can be designed to require collaboration and problem-solving among the team members, promoting effective communication and teamwork. By including a variety of task types, such as coding exercises, role-playing scenarios, or interactive quizzes, players can engage with different aspects of Agile methodologies and deepen their understanding.

Another proposed change is to incorporate a system of rewards and incentives to motivate players and maintain their engagement throughout the gameplay. For example, players could earn work credits or unlock special features by successfully completing tasks or achieving specific milestones. These rewards can then be used to access additional content, customize avatars, or unlock new abilities, providing a sense of progression and personalization within the game. Similarly,

implementing the planned shop functionality would significantly increase the incentive to play the game.

Lastly, it is important to consider player feedback and iterate on the game's balancing and difficulty levels. Carefully adjusting the challenges and scaling the gameplay appropriately would make the players feel consistently challenged and not overwhelmed or bored. This requires thorough playtesting and more iterations of evaluations from the target group to ensure that the game provides an appropriate level of challenge and maintains a sense of progression. With these proposed changes, the total content and variety in Digital Descent can be considerably increased, addressing the reported issues and improving the gameplay experience for the players. These improvements will not only make the game more pleasant and engaging, but they will also promote a more effective learning experience by giving players with a broader range of opportunities to apply Agile principles and grow their abilities.

Chapter 10

Conclusion

This chapter summarizes the main contribution of this master thesis to the field of serious games designed for learning Agile Software Development. The contributions presented are the game concept and the final prototype presented in chapter 4 and chapter 5, its creation process alongside a benchmark framework and comparison test on some of the most popular web-based game and rendering engines in chapter 6, and its evaluations in chapter 7, chapter 8 and chapter 9.

10.1 Research Questions

The research questions of this thesis serve as the foundation for all the research carried out during the course of this thesis. This section will look to answer the research questions presented in chapter 1, and discuss the degree to which the research questions were answered.

RQ1: How can a simulation-based serious game be made to teach Agile methodology concepts?

This thesis seeks to create a serious game that will engage and entertain students while teaching them the concepts of Agile. The work had previously begun as a specialization project, with the goal of examining how serious games may be built to successfully teach Agile methodology concepts. While the specialization project researched existing literature and concluded that simulation-based serious games effectively improved learning, this thesis covers the research on game elements, development, and prototype of a serious game for teaching Agile methodology concepts. The answer to the main research question **RQ1** is thus based on the findings of its sub-questions and is formed from the knowledge acquired throughout the chapters. This thesis describes in detail the design, development, and evaluation of the serious game Digital Descent.

In chapter 4, a comprehensive list of game elements and learning objectives for designing a simulation-based serious game to teach Agile methodology concepts is presented. These elements and objectives were implemented and evaluated in

the serious game Digital Descent, where it was later revealed in the evaluations that the game concept and prototype of Digital Descent effectively served its purpose of teaching Agile Software Development concepts while keeping the players engaged. However, due to constraints such as limited time and project scope, the game prototype was not fully developed as initially planned, which hindered the extent of knowledge transfer the game aimed to provide as discussed in section 9.5. Although the main research question is partially addressed through the game design of Digital Descent, a more complete answer would have been possible with the realization of all the planned game features. Nevertheless, future projects within the same field of work can utilize Digital Descent as a foundation for developing new games with similar objectives.

RQ1.1: How can simulation-based games be designed to educate players on the educational topic of agile software development, as well as the significance of communication and collaboration?

To address the research question **RQ1.1** of how simulation-based games can be designed to educate players on the educational topic of Agile Software Development while emphasizing the significance of communication and collaboration, a thorough exploration of existing serious games and their game design was conducted in chapter 3. This investigation aimed to identify successful game elements and mechanics used in existing games that promoted motivation, collaboration, and communication, as well as addressing the challenges and limitations in similar contexts we could build on. The findings from this exploration shed light on the game elements and mechanics that were proven to be successful, and served as a foundation for the design and development of Digital Descent, a serious game specifically designed to teach Agile methodology concepts.

The exploration highlighted the critical role of communication and collaboration within Agile teams, emphasizing that game scenarios and challenges that actively engage players in communication, coordination, and teamwork as game elements. are design choices that a simulation-based game should implement. Addressing this, Digital Descent were designed to simulate the Agile team dynamics, placing players in the role of Agile software developers were they had to collaboratively work on the same goal and objective. It is by immersing the players in Agile scenarios and providing them feedback on their decisions and actions, that the players get to experience firsthand the value of effective communication and teamwork in Agile Software Development. The decisions done by the players that is deemed positive for the game progression should be rewarded, and vice versa if not, as it pushes the players to focus on streamlining the team's collaboration during gameplay. Additionally, the incorporation of instructional design principles in the game were found to play a vital role in facilitating learning and knowledge transfer from the Agile game environment to real-world circumstances. To ensure effective instructional design, Digital Descent includes various game elements such as tutorials, interactive dialogues, and feedback mechanisms. These

elements reinforce learning, enhance player engagement, and facilitate the application of Agile principles in practical settings.

Overall, the research on related works and the subsequent design of Digital Descent address the research question by offering insights into effective game elements and design strategies. With this, a simulation-based serious game can be effectively designed to provide effective education by leveraging engaging game elements, simulating Agile team dynamics, and incorporating instructional design principles similar to the design choices incorporated in Digital Descent as discussed in chapter 5.

RQ1.2: How can the game be designed so that it is available and easy to access to a wide audience while still complex enough to illustrate the real-world environment of Agile Software Development?

Similar to the exploration conducted on existing simulation-based serious games in chapter 3, it was observed that ease of access and the specificity of target audience and setting were one of the most common limitations in previous games (Le & Ngo, 2022). To address **RQ1.2**, careful architectural and design choices were implemented in Digital Descent, as presented in chapter 6.

In terms of availability, the chosen tech stack for Digital Descent relied on web technologies, which played a crucial role in enhancing the game's availability. This web-based technology stack enabled a wide range of players to access and play the game, regardless of their operating system or hardware specifications, as long as they had access to a browser and internet connectivity. This decision aimed to ensure that the game was widely available and easily accessible to a broad audience, eliminating the need for any installations.

While the emphasis was placed on ease of access and availability, observations and evaluations revealed some usability issues in certain game elements, which did not maintain the required complexity to illustrate the real-world environment of Agile Software Development as intended. For instance, it was found that the players encountered challenges during the battle scenes against the bugs, sometimes unsure of what actions to take, and concerns were raised about the game's balance becoming too easy after a certain point. These observations indicated a need for further fine-tuning and improvement in the progression of difficulty.

However, despite these challenges, Digital Descent incorporated game mechanics, scenarios, and decision-making processes that accurately mirrored the intricacies of the Agile Software Development process. The key takeaway is that the user interface (UI) and visual design of the game are just as important as the game concept itself and should be carefully crafted to prioritize usability and intuitiveness. Therefore, clear instructions, intuitive controls, and user-friendly interactions are important design choices that a serious game should incorporate to ensure that players, regardless of their familiarity with Agile concepts, can easily navigate and engage with the game. Despite the identified limitations, the design of Digital Descent lays a strong foundation for future work and improvements.

RQ1.3: Can we overcome the challenges associated with Agile learning by creating a game for Agile Software Development that incorporates motivating game elements?

The challenges associated with Agile learning were found to be similar to those encountered during Agile adoption, primarily stemming from human factors, as discussed in subsection 2.3.3. Overcoming these challenges and ensuring successful Agile learning requires students to grasp the principles and practices of Agile methodology. Therefore, the effectiveness of the game in achieving this goal as well as answering the research question **RQ1.3**, strongly depends on whether the four learning objectives discussed in chapter 4, which the game aims to teach, are promoted throughout the gameplay.

Digital Descent underwent an iterative design process, involving the active participation of students, as well as experts in agile methodologies and game design through three prototype evaluations. Through the multiple rounds of evaluation and feedback, the game prototype demonstrated significant potential in various aspects, indicating its viability as an effective educational tool for the learning of Agile Software Development (ASD) concepts. During the final evaluation, participants expressed enthusiasm for the game concept, considering it to be an original and innovative idea. While they initially found the game to be engaging and immersive, it was noted that the experience became repetitive and less engaging over time due to the limited variety and content available, as discussed in section 9.5.

Although the serious game Digital Descent fell a bit short in effectively promoting two out of the four learning objectives, specifically **LO3** and **LO4**, it successfully facilitated participants' understanding of Agile concepts. The evaluation results highlight the game's ability to enhance the students' comprehension of Agile methodology concepts by incorporating motivating game elements. While this evidence partially validates the effectiveness of Digital Descent as an educational tool for teaching Agile Software Development concepts, it should be noted that the evaluation was conducted with a limited number of participants. Therefore, in order to draw a more definitive conclusions and validate the game's effectiveness, further work on the prototype, as well as evaluations with a larger and more diverse participant pool, are necessary.

10.2 Strengths and Limitations of the work

The findings of this thesis are based on a triangulation of data obtained through various data collection methods. The game concept of Digital Descent underwent a qualitative evaluation with the target group through a focus group. Similarly, the evaluation of the game prototypes involved the collection of qualitative data through observations, focus groups, and interviews with the target group, as well as agile and game experts. These qualitative data collection methods provided the participants with the opportunity to engage in in-depth discussions, share their

perspectives, and provide valuable insights and feedback on the game concept and prototype. This qualitative evaluation process allowed the author to gain insights into the participants' perceptions and preferences, enabling the author to gain a deeper understanding of how Digital Descent could be improved to serve its intended purpose and successfully teach the desired learning objectives. The triangulation of the data gathered from the qualitative sources helped improve the validity of the results presented. However, it is important to recognize some limitations of these data collection methods, as the evaluation of the game concept and prototype predominantly relied on qualitative methods. Although qualitative data yielded valuable insights into players' experiences and perceptions, incorporating a quantitative analysis could have enhanced the understanding of the effectiveness of the game elements. Furthermore, the evaluation process involved a relatively small sample size, which could potentially restrict the generalizability of the findings. Conducting future evaluations with a larger and more diverse participant pool would strengthen the validity and reliability of the results.

Additionally, the identification of engaging and effective game elements that facilitate learning has been a primary focus and contribution of this thesis. Through the literature review and rigorous evaluation, key game elements that promote engagement and facilitate learning were identified. Most of these elements were carefully integrated into the game design of Digital Descent to create an immersive and educational gameplay environment. However, it should be noted that not all of the identified elements were fully implemented as in the final prototype as initially planned due to time constraints. This limitation may have impacted the overall gameplay experience and the game's potential to facilitate optimal learning outcomes. This limitation is not a significant drawback, as the maintainability of the game design and technology stack enables for future iterations and additions to be easily added. This emphasis on maintainability and availability is one of the strengths of the game design in Digital Descent. Unlike many previous games in the same context identified in chapter 3, Digital Descent utilizes a technology stack that allows for easy maintenance, ensuring that the game can be continuously updated and made readily available to users as presented in chapter 6. This aspect contributes to the longevity and sustainability of Digital Descent as a game, providing opportunities for future enhancements and improvements easily.

Another notable strength of Digital Descent is its unique combination of being an online collaborative game with a strong resemblance to entertainment games, despite its serious educational focus. The incorporation of selected motivational and engaging elements listed in Table 5.1 sets it apart from traditional serious games, and creates an immersive and enjoyable gameplay experience for the players. By blending entertainment with educational content, Digital Descent offers a novel approach to learning Agile methodologies, making it more appealing and engaging for the target audience.

Furthermore, extensive research and effort were dedicated to developing the game environment in Digital Descent. The game art, scenario, and context were carefully drawn and crafted to simulate the experience of working in an Agile

development team. This attention to detail and authenticity contributed to the overall effectiveness of the game in teaching Agile concepts and improving the players' understanding and application of Agile methodologies. This was particularly expressed by participants in all iterations of the evaluations.

10.3 Recommendations for Future Work

In the context of future work, several recommendations can be made to further enhance Digital Descent and its potential as an educational tool for teaching Agile Software Development concepts. As the primary contribution of this master thesis, the design of the serious game Digital Descent holds significant importance. To address the weaknesses identified during the evaluations of Digital Descent, it is recommended to expand the game's content and features, as proposed in the main evaluation presented in subsection 9.5.4. These proposed changes aim to cover a wider range of Agile Software Development concepts and scenarios, thereby increasing the game's educational value. This expansion would involve incorporating additional challenges that delve into specific aspects of agile methodologies, enabling players to further develop their understanding and skills in applying Agile practices. Furthermore, to promote the development of essential teamwork skills, it is advisable to consider integrating new types of collaborative features that foster teamwork and cooperation among players. The inclusion of a more varied team-based challenge, such as puzzle-solving challenges, could better simulate real-world agile team dynamics.

Additionally, due to the limited variety and content accessible in the game prototype, the experience of Digital Descent became repetitive and less engaging over time during the gameplay. Incorporating extra motivating game elements such as rewards and incentives to motivate players throughout gameplay, as well as balancing game difficulty and scaling, were some of the adjustments mentioned in the main review.

Lastly, to further strengthen the findings and validate the effectiveness of Digital Descent, it is recommended to conduct additional evaluations with a larger and more diverse participant pool. By including a broader range of perspectives and insights, these evaluations would provide a more comprehensive understanding of the game's impact and ensure its suitability for a wider audience. Addressing the limitations identified in the current work, such as the absence of quantitative analysis, would enhance the evaluation process as well. Incorporating quantitative measures, such as pre- and post-game assessments or knowledge tests, would provide more objective data on the learning outcomes and enable a more comprehensive evaluation of the game's effectiveness.

In conclusion, this thesis and the game concept and design of Digital Descent have served as a solid foundation for future work in the field of simulation-based serious games for learning Agile Software Development concepts. The insights gained from this research can all in all guide and inspire future researchers and developers who wish to create similar educational resources.

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Appendix A

Interview guide

A.1 Purpose

The primary objective of this study is to garner a professional perspective on the game and receive constructive feedback.

A.2 Process

The study process is divided into the following stages:

A.2.1 User Test

The User Test consists of a set of tasks which will be completed by the participants. The user test have the following tasks:

- Start a game session with someone
- Arrive at the digital world
- Complete the first battle (Reach day 2 of the iteration)
- Reach day 6 of the iteration

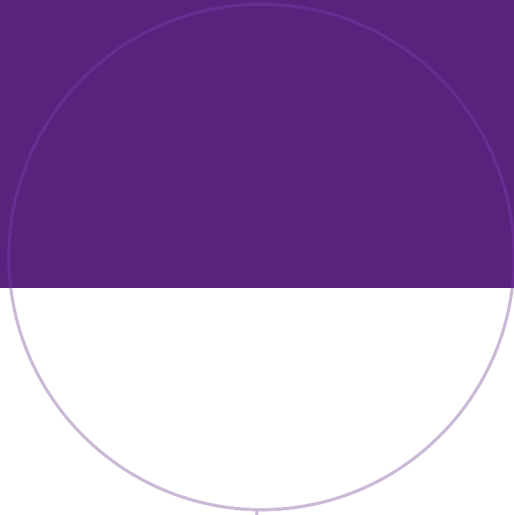
A.2.2 Interview

There will be a structured interview. The questions are listed below and are divided into general, learning outcome and game-related and engagement.

General	
Questions	Rationale
What is your first impression of the game?	Assess the player's initial thoughts and impressions during their first experience with the game.
What did you like the most about the game and why?	Identify the specific parts or elements of the game that the player enjoyed the most and gather feedback on their positive aspects.
What did you like the least about the game and why?	Identify the specific parts or elements of the game that the player disliked the most and gather feedback on areas that need improvement.
Who do you think the game is suitable for?	Evaluate if the game effectively targets the intended audience.
Is the game suitable for new graduates in terms of content and the amount of Agile background information provided?	Assess if the game has been adapted to be suitable for the target group.
Did you encounter any challenges with the game?	Determine if the player faced any difficulties or encountered challenges while playing the game.
Learning outcome	
Questions	Rationale
Can you see the connection between Agile and the game elements used to teach Agile? Can you provide examples of the game elements that are related to Agile?	Determine if the person is aware of which game elements contribute to or are related to Agile. Confirm if the elements we have used in the game are perceived as intended.
Are there any game elements you feel are missing in terms of learning the Agile mindset?	Gather ideas for additional functionalities.
What do you feel you will learn the most from the game?	Identify which elements contribute the most to the learning experience.

Game-related and engagement	
Questions	Rationale
How entertaining was the game?	Assess the level of enjoyment experienced while playing the game.
How challenging was the game for the target audience?	Determine the level of difficulty encountered by the target audience.
Were the help and information texts provided during the game phases sufficient?	Evaluate the adequacy of the provided help and information texts in aiding gameplay.
Does the game effectively promote collaboration through the game elements used?	Assess if the game elements effectively encourage collaboration among players.
Did the game facilitate communication and discussion between players? Which parts of the game do you feel facilitated the most discussion among players?	Determine the extent to which the game facilitated communication and identify the game elements that promoted the most discussion.
What are your thoughts on the game's game loop? Is it too repetitive considering the iterative tasks?	Gather feedback on the implementation of the game loop and its perceived repetitiveness in relation to the iterative tasks.
What are your thoughts on the implementation of the task board in the game?	Gather feedback on the implementation of the task board and its effectiveness in enhancing gameplay.
Additional Suggestions	
Questions	Rationale
Do you have any other suggestions for improvements or new features we could add?	Gather any additional suggestions for enhancing the game.

Table A.1: Evaluation Questions



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