Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

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Utilising Collaboration in Escapade: An Engaging Learning Game

Master's thesis in Computer Science
Supervisor: Alf Inge Wang
June 2022

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Abstract

Learning games tend to either be enjoyable and lack a learning effect or have solid educational foundations without being fun to play. Striking a balance between the two sides is challenging and requires careful consideration of design decisions. Collaborative elements have long been a mainstay in video games, and utilising them in a learning game could potentially result in a game that engages and educates players.

Following a literature review on learning theory, game design, and current learning games, a concept for our game, Escapade, was created. Escapade is a game that lets players see a picture of a historical event and team up to figure out what event it is, when it happened, and where it took place. After multiple design iterations, the game was developed into a prototype that could be used to assess its effect on students.

An experiment was held in two upper secondary school history classes where 36 students played the game. To examine the effect of the game's inclusion of *the jigsaw method*, the two classes played the game with different rules. The jigsaw method splits a topic into pieces and distributes them among students, forcing students to communicate to obtain all the pieces. We implemented this in our experiment by not allowing participants to look at each other's screens in one class (the jigsaw class) while encouraging it in the other (the non-jigsaw class).

The resulting data on participants' motivation, engagement, enjoyment and perceived learning was then analysed and discussed. The experiment revealed that the game had a positive impact on participant motivation and that they found it engaging and enjoyable. The inclusion of the jigsaw method led to higher levels of perceived learning among participants, with those in the jigsaw class also reporting that the game could bring them more value than those in the non-jigsaw class. We also found that interest in video games and history significantly impacted how participants experienced the game positively.

Sammendrag

Læringsspill har en tendens til å enten være gøy og mangle læringseffekt, eller ha et godt utdanningsgrunnlag uten å være gøy å spille. Å finne en balanse mellom disse to elementene er vanskelig og krever at man tenker nøye gjennom designvalg. Samarbeidselementer har lenge vært vanlige i dataspill, og ved å bruke dem i et læringsspill kan man potensielt få et spill som er engasjerende og lærerikt.

Etter å ha gjennomført en litteraturstudie om læringsteori, spilldesign og aktuelle læringsspill, laget vi konseptet for spillet vårt – Escapade. Escapade er et spill der spillere ser et bilde fra en historisk hendelse. Som et lag skal de finne ut av hvilken hendelse det er, når det skjedde og hvor det fant sted. Etter flere designiterasjoner ble spillet utviklet til en prototype for å undersøke effekten konseptet kunne ha på elever.

Et eksperiment ble utført med to klasser på videregående nivå med til sammen 36 deltagere. For å vurdere effekten av spillets bruk av puslespillmetoden, på engelsk *the jigsaw method*, spilte de to klassene med forskjellige regler. Puslespillmetoden deler et tema inn i flere deler og fordeler disse mellom elevene. Dette tvinger elevene til å kommunisere med hverandre for å få tak i alle delene. Vi implementerte dette i eksperimentet ved å ikke la deltagere se på hverandre sine skjermer i den ene klassen (puslespillklassen) mens vi oppfordret til det i den andre klassen (ikke-puslespillklassen).

Dataen innhentet om deltakernes motivasjon, engasjement, fornøyelse og opplevd læringseffekt ble så analysert og diskutert. Eksperimentet viste at spillet hadde en positiv effekt på deltakernes motivasjon og at de syntes det var engasjerende og gøy. Bruk av puslespillmetoden førte til høyere opplevd læringseffekt. I tillegg til dette meldte elevene i puslespillklassen at spillet kunne gi de mer verdi enn hos elevene i ikke-puslespillklassen. Vi fant også ut at interesse for dataspill og historie påvirket spillopplevelsen positivt.

Acknowledgements

We want to thank our supervisor, Professor Alf Inge Wang, at the Department of Computer Science at The Norwegian University of Science and Technology (NTNU) for the opportunity to work on this project and for his support and guidance throughout the semester. His knowledge and experience have been crucial in every stage of this project, and his dedication to providing us feedback, especially during our weekly meetings, has been invaluable. We would also like to thank teachers Ove Sollazzo Syrstad and Arnt Selnes and their students from Kristen Videregående skole Trøndelag for allowing us to test our game during their classes.

Finally, we would like to thank Inga Foss, our classmates, friends, and families, who helped us by listening to us talk about our project and provided valuable suggestions, criticism, and support.

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Part I

Introduction

This part will first present our motivations for choosing this task and its use to society. We will then introduce the task description and some context for the project. Afterwards, we will formalise a research goal for the project through research questions and metrics, followed by a description of our research method. Finally, a brief reader's guide will be presented, which describes the structure of the remaining thesis.

Chapter 1

Motivation

It is no secret that engagement is a crucial part of the learning process, and a student's level of engagement has been shown to affect their learning outcome [1]. Since their inception in the 1970s, video games have mastered the task of keeping players engaged. Combining video games with learning, creating educational video games, seems like a perfect match. Educational video games are no new concept, with researchers seeing this potential decades ago [2]. Studies have shown that educational video games can be an effective tool for learning [3, 4, 5]. Cooperative elements can have a positive impact on the level of engagement a video game commands, exemplified by the enormous success of massively multiplayer online role-playing games (MMORPGs), online first-person shooter (FPS) games, and later, multiplayer battle arena (MOBA) games. Cooperative elements in educational games have been shown to affect the learning process positively [6].

Motivating students is crucial in enabling them to learn, and the use of video games in learning has been shown to increase students' motivation toward a topic [7]. Whereas engagement regards the player's engrossment in the moment, motivation regards their long-term willingness to learn and is equally important. Creating a game that helps students stay motivated in their learning process motivates this project and us personally.

As both of us have experienced the educational potential of video games, we found this task fascinating. Gaming is becoming increasingly common, with 86% of Norwegian youth between the ages of 9 and 18 reporting playing video games [8]. Using a familiar medium to improve the effectiveness of education could have a positive societal impact, which is a motivating factor for us. We both have part-time experience teaching through student assistant and tutor work and enjoy reaching through to students in engaging ways. Additionally, we are both interested in game design and development and have previously dabbled with individual game projects in our free time.

Another motivational factor is the opportunity to thoroughly research game design mechanics to design an enjoyable and engaging game that keeps players playing *despite* its educational component rather than *because* of it.

Chapter 2

Project and Context

This master's thesis is part of the master's programme at the Department of Computer Science (IDI) at the Norwegian University of Science and Technology (NTNU). It was written in Spring 2022 and is a continuation of our specialisation project from Autumn 2021 [9].

The task description for this master project reads:

> *"**[Lecture Games] Collaborative classroom learning games***
>
> *The goal of this project is the design, implementation and evaluation of a collaborative learning game, where the students together beat the game and at the same time learn. The game will have to balance engagement and learning to make it fun and educational. Another requirement is that the game must be a multiplayer game where all the students in a call can participate simultaneously.*
>
> *The project will involve a study of research on game-based learning, designing and implementing a concept, and evaluating the concept with users."*

This project can be split into four stages. The first two stages made up the specialisation project, while the last two will be addressed in this thesis as part of the master's project.

The first stage consisted of conducting research into theory on learning, game-based learning, and video game enjoyment. Furthermore, it explored video games and technology relevant to the project. We created a framework for categorising educational games based on what we learned.

In the second stage, we applied findings from the first stage to create six collaborative learning game concepts. We compared these concepts and selected a concept for further development and testing. This concept is implemented in the third stage of this project. In the fourth and final stage of the project, the game is tested in two upper secondary school history classes and the data gathered is analysed.

Chapter 3

Research Goal and Questions

This thesis will use the Goal, Question, Metrics (GQM) approach [10] to decompose this project into a specific goal. The three levels of GQM start on a conceptual level, finding a goal based on the project's purpose. The next level is operational and includes a collection of questions to measure whether or not the purpose of the project is achieved. The last level is quantitative and describes how we will answer the questions through a concrete collection of research metrics.

3.1 Research Goal

The research goal of this project is:

> *To design, develop, and test a collaborative learning game that is both engaging and educational.*

It is split into multiple research questions, which will be answered separately to evaluate the goal.

3.2 Research Questions

We have constructed the following research questions to break down our research goal into individually assessable elements.

RQ1: *Which elements make a cooperative learning game enjoyable, engaging, and educational for players?*

RQ1 will be answered in a prestudy based on the project's specialisation report conducted before this master's thesis. Answering this RQ as thoroughly as possible is crucial for the project's concept creation phase, as it provides a good grasp of which elements to include and emphasise to best fulfil the project's research goal.

RQ2: *How does playing our game affect players' motivation towards the subject presented by the game?*

One of the potential benefits of using video games in education is an increased motivation for the subject presented by video games. With RQ2, we aim to analyse the presence of such an

effect in our game through player feedback.

RQ3: *To what degree does our game enable collaboration between multiple players in a way that promotes learning?*

To evaluate the educational aspect of our game, we need to examine how the game's collaborative elements encourage learning among players. RQ3 will be answered through player and teacher feedback and observations from our experiment.

RQ4: *How is player engagement affected by the game's collaborative elements?*

RQ5: *How is player enjoyment affected by the game's collaborative elements?*

RQ4 and RQ5 pertain to how collaboration between players affects their engagement and enjoyment of the game. Player engagement and enjoyment are central parts of our research goal, and quantifying how the game's collaborative elements impact these is important in obtaining a holistic view of the effect of the game's collaborative aspect. Player feedback and observations from our experiment will help the primary ways we evaluate these questions.

RQ6: *How is the gameplay experience affected by a player's interest in video games and history?*

The gameplay experience may be better for players who frequently play games or are interested in history. Our game is intended for classroom use and should thus ideally engage players regardless of their interest levels. To evaluate RQ6, we will use player feedback, specifically by analysing the relationship between facets of players' experiences and players' interest in video games and history. These facets include motivation, collaboration and learning, enjoyment, and engagement.

3.3 Summary

This chapter has presented our research goal and questions, which will guide the direction of our work in this project. The research goal represents the project's overarching goal, while the research questions (RQ1-RQ6) serve as individually addressable questions that make up the research goal.

Chapter 4

Research Methods

To help structure our project, we have based our research process on the research model described by Oates in her book, *Researching Information Systems and Computing* [11]. Oates's research process model is shown in Figure 4.1, with the elements used in this project having a blue shade. Oates presents this model as a description of a process which leads to answers to research questions. Research questions and a conceptual framework can be created with the researcher's own experiences and motivations in addition to a literature review. From here, one or more strategies are chosen, where strategies are various ways of finding answers to research questions. Data generation methods are then selected, with analysis of said data being the final step before the research is presented. This chapter will go through each of the steps in this process relevant to this project.

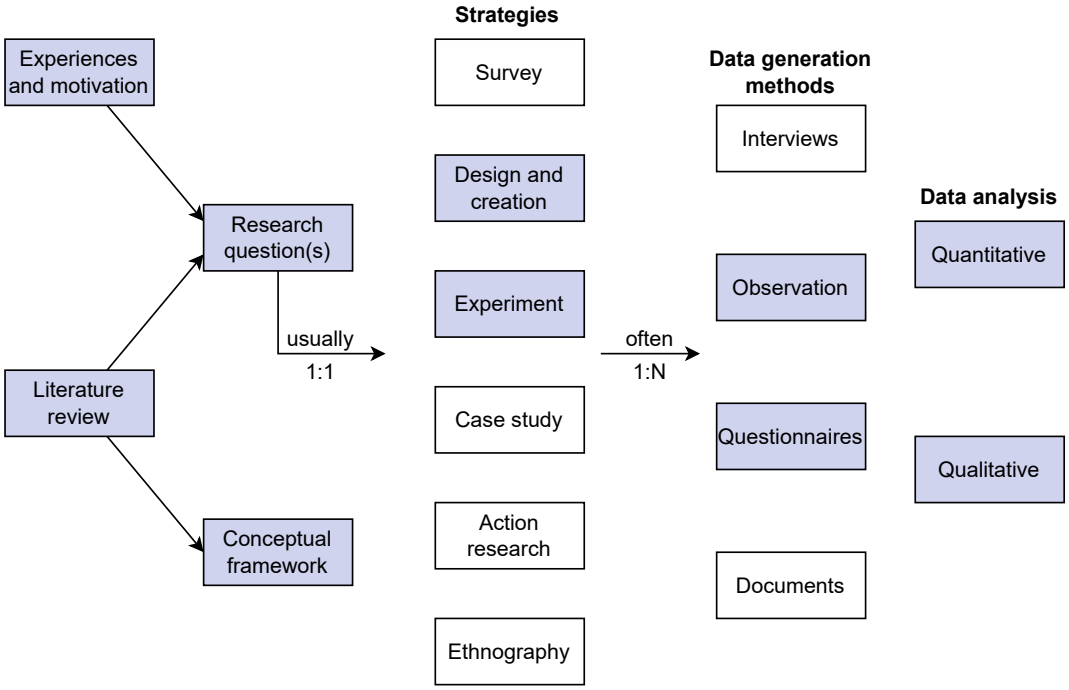


Figure 4.1: Oates's model of the research process

4.1 Experiences and Motivation

Alongside a literature review, which will be described in the following section, Oates describes researchers' experiences and motivation as the first step in the research process. In our case,

our interest in video game development and game-based learning has undoubtedly shaped the project. Examples of this include the decision to investigate use of the jigsaw method [12] (see Chapter 7) in game-based learning, the idea for which came from our personal experience with games like *Keep Talking and Nobody Explodes* [13] (see Section 14.1). Our experience has also shaped our development process and choice of technology, which is further expanded upon in Chapter 22.

4.2 Literature Review

Conducting a literature review is an essential early step in most research and comprised a significant part of our work during the specialisation project. Oates lists many common objectives with literature reviews which apply to our project. Our literature review's most important role was familiarising us with current theory in learning, game design, and game-based learning. This knowledge served multiple purposes. Firstly, it helped us design a fun and engaging game concept. It also helped us identify factors we wished to examine during our experiment. It allowed us to communicate the theoretical basis for our game concept, playing a significant part in the resolution of RQ1 (research questions are presented in Section 3.2). The literature review also investigated current games relevant to our project. This review consisted primarily of collaborative games and learning games.

During our literature study, we applied some of the guidelines recommended by Snyder in her article on literature review as a research methodology [14]. One of the recurring themes in Snyder's guidelines is the need to keep the goal of the literature review in mind when choosing a strategy for how to search for, select, analyse and communicate the study. For us, this initially meant leaning on our supervisor for assistance in selecting articles. As someone with broad experience in game-based learning, he helped us choose articles that would be useful for our project. Following this, we adapted our search to support our concept creation process, adjusting it as we hit different stages. As we chose a concept to develop further, we focused the literature study on research that would be especially relevant for that specific concept. This approach resulted in our literature review process at times having an ad-hoc structure, which contradicts Snyder's recommendations. It might have been advantageous to plan these various stages explicitly, though we did not experience any issues with how we conducted our review.

In discovering interesting and relevant theories during our literature review, we made a conscious effort to find more articles on the same topic to ensure a nuanced view. Furthermore, for our approach to source criticism, we employed the CRAAP test [15], which had us evaluate the

currency, relevance, authority, accuracy and purpose of a source to judge whether a citation was suitable for our literature review.

4.3 Research Questions

As described in Chapter 3 we have an overarching research goal in this project, which we have divided into multiple research questions. These research questions serve as concrete guides on where to focus our research. RQ1 necessitates a different methodology than the other research questions. Its answer is found primarily in our literature review and the following design and creation process rather than in experimentation. This methodology is an excellent example of how research questions guide our research process. Without this research question, the objectives, and therefore the structure, of our literature study would have been very different.

4.4 Conceptual Framework

A conceptual framework, according to Oates, serves to ”make explicit how you structure your thinking about your research topic” [11]. Our project employs it in the form of a framework that categorises educational games according to various properties, such as platform, audience, and interaction. This framework is used to compare existing games and is utilised in the selection process when deciding on which concept to develop further (see Chapter 18). Using a conceptual framework helps ensure we are on the same wavelength internally in the project and aids in communicating our research process in this thesis.

4.5 Strategies

Strategies, in this context, refer to the way we intend to answer a research question. Oates mentions that it is most common to see one research question employ only one strategy; this is also the case in this project.

Design and Creation

Design and creation is a strategy that focuses on the creation of new IT *artefacts*. Artefacts, in this context, refers to a multitude of things, be they concepts, models, methodology, or computer systems. The thought behind using design and creation as a strategy is that the process enables researchers to *learn by doing*. Oates lists five stages that make up this process:

- **Awareness**: Gaining awareness of the problem that the new artefact will help solve is often accomplished through talks with potential users of the artefact or by studying literature.
- **Suggestion**: Making initial suggestions as to how to solve the problem(s) identified in the previous stage through the creation of an artefact.
- **Development**: The idea constructed in the previous stage is implemented.
- **Evaluation**: Assessment of the artefact worth and comparison to the expected result.
- **Conclusion**: Knowledge gained during the process is summarised and communicated. This stage can also include pointers for further research.

In this project, the design and creation strategy is used to answer RQ1. Due to the artefact in this project being a video game, our development stage consists mainly of two elements. These are software development and an iterative process to fine-tune the gameplay content, with informal game tests to gauge the effectiveness of the current game version along the way. The development process is covered in detail in Chapter 24.

Experiment

To gain answers to research questions RQ2-RQ6, we will experiment. Experiments, according to Oates, ”seek to prove or disprove a causal link between a factor and an observed outcome”. RQ2-RQ6 concerns our game’s effects on player motivation, collaboration, enjoyment, and engagement. They are well-suited to be answered by experimentation by letting players try the game and provide us with their thoughts afterwards. In this project, we will run an experiment with two different groups of students in their upper secondary school history class. The players will be given slightly different instructions for the experiment to examine the effect of one of the game’s design elements. The project’s experiment is described in Part IV of this thesis.

4.6 Data Generation Methods

This project will use questionnaires and observation as data generation methods, which we will apply during the experiment mentioned in the previous section. As indicated by Figure 4.1, a single strategy often has multiple data generation methods associated with it. Using various data generation methods to examine the same element is referred to by Oates as *method triangulation* and increases the validity of the data gathered [11].

Questionnaire

Our primary data generation method will be the questionnaire, with players being asked to fill out a questionnaire after playing the game during an experiment. The questionnaire will provide quantitative data through statements to which answers are given on a five-point Likert scale [16]. It will also provide us with qualitative data through long-form responses. Questionnaires offer data that is easy to analyse and compare due to the often standardised nature of responses.

Observation

Observation is the practice of observing participants and analysing their actions instead of the answers provided by the participants themselves. Observation comes in multiple forms, with *overt*, *participant participation* being used in this project. Being overt instead of covert means that the participants know they are being observed. The observer is part of the same situation as the participants in participant observation. The alternative to participant observation is systemic observation, where an observer pre-selects certain events to observe and note their frequency or duration [11].

4.7 Data Analysis

To analyse our data, we will first divide it into quantitative and qualitative data and then proceed with the analysis. We will discuss the reliability and validity of the data in Chapter 28.

Quantitative

Quantitative data, the main product of our questionnaire, will be presented and analysed with the help of graphs, tables, and nonparametric statistical methods. The Mann-Whitney U test will gauge the degree of significance [17], while Spearman's rank correlation coefficient will evaluate correlation [18]. The quantitative data from the experiment will help us judge how players experienced our game and are crucial to answering our research questions regarding players' experiences. Quantitative analysis of our qualitative data might also be prudent, for example, by looking at the frequency of different themes or words in responses to the questionnaire's open-ended questions.

Qualitative

Our experiment collects qualitative data through open-ended questions in the questionnaire and our observation. This data will be used to assign reasons for the effects seen through our quantitative data, should any clear pattern emerge.

4.8 Summary

This chapter has summarised our research methodology, which will serve as the basis for our experiment and the data gathered. How each step of this process is carried out will be explained further in subsequent parts of this thesis.

Chapter 5

Reader's Guide

This chapter provides an overview of the thesis's six main parts by summarising the topics of their chapters in the order they appear.

Part I – Introduction

Part I introduces the project by giving an overview of the task, methodology, and motivations. It begins by presenting both societal and personal motivations for this project. Afterwards, we provide the complete task description and the task's context. Following this, we outline the research process through a research goal and research questions. Finally, the reader's guide provides the reader with information about the structure of this thesis.

Part I is recommended for readers who wish to obtain an overview of the project, our motivations, and a description of the project's research methodology.

Part II – Preliminary Study

Part II is based on work accomplished in the specialisation project [9]. It begins by providing the theoretical basis for this project by summarising articles, studies, and books that have informed the design decisions made in this project. This theoretical basis primarily comprises materials on learning theory, enjoyment of video games, and game-based learning. It then covers existing educational and collaborative games relevant to this project, categorising them and analysing their influence on our project. Finally, an overview of pertinent technology is provided.

Part II is recommended for readers interested in the theory behind the design decisions in the project's game concepts.

Part III – Our Solution

Part III describes the process of creating and developing a game concept to be tested in this project. First, the six game concepts created for the project are presented, along with a description of the selection process. Then, the game is described and elaborated on using theory from Part II. The game's requirements are then laid out, followed by a description of its software architecture. Following this, the technologies chosen for the game are presented along with the

development process. Results from the test of the game's requirements conclude Part III.

Part III is recommended for readers interested in how we selected the game concept and the process of developing this concept into a functioning prototype. The background for many of the decisions made in this part is provided in Part II.

Part IV – The Experiment

Part IV describes the experiment in which we tested the game prototype. It also details which data was collected, along with its purpose. Finally, a description of reliability and validity concerns that might impact the results is presented.

Part IV is recommended for readers interested in how the experiment and data gathering was executed.

Part V – Results

Part V begins by discussing the test population of the experiment. Following this, results on players' concentration, engagement, enjoyment, motivation, and learning outcome are presented. This section also compares differences in results between subgroups in the test population and examines relevant correlations for the project's research questions.

Part V is recommended for readers who wish to explore the results of the project's experiment. Discussion of these results regarding the research questions and goal is primarily covered in Part VI.

Part VI – Discussion and Conclusion

Finally, Part VI concludes the results presented in Part V and uses this data to answer the research questions and assess the research goal. The project is also evaluated, and some suggestions for future work in the field are presented.

Part VI is recommended for readers who wish to read about the conclusion to this project and are interested in our thoughts on how this research should continue.

Part II

Preliminary Study

This part will summarise the articles we have used as a theoretical basis for our project. It will cover the basics of learning theory and theory specific to game-based learning and the mechanics we will include in our game. It will also cover ideas regarding how to make enjoyable video games. Subsequently, existing games relevant to our project will be presented and compared using our categorisation system, followed by a summary of current state-of-the-art game development technology. This part is based on our specialisation project [9].

Chapter 6

Basics of Learning

As this project is centred around using video games to promote learning, it is natural to cover current prominent theories of learning, at least at a fundamental level. This chapter will primarily refer to the well-known book *Ways of Learning: Learning Theories and Learning Styles in the Classroom* by Alan Pritchard [19]. Pritchard mentions multiple definitions of learning, one of which reads *"To gain knowledge of, or skill in, something through study, teaching, instruction or experience"*. Pritchard also describes the field of learning theory as split into two primary branches, *behaviourism* and *constructivism*. He stresses that diverse theories exist within each branch but asserts that this fundamental split is "fair". This chapter will summarise each branch and look at its most influential concepts. Due to the scope of this thesis, we will limit ourselves to describing the two branches Pritchard presents. Examples of other prominent learning theories that we will not cover in this thesis are cognitivism, which stems from cognitive psychology and is closely related to constructivism [20], and humanism, which focuses on how the learning process is one of self-actualisation [21, 22].

6.1 Behaviourism

The oldest of the two branches, behaviourism, sprung to life in the late 19th and early 20th centuries. Stemming from intentions to focus only on what is directly observable, behaviourism discounts internal mental processes favouring something more concrete. Behaviourists argue that any behaviour is nothing but a response to a person's stimuli. As a result, behaviourists describe learning as the creation of specific responses to certain stimuli through the process of *conditioning*. A student answering "36", when asked to square the number 6, responds to the stimuli of being asked this question with a response formed through repeated practice or conditioning. From a behaviourist perspective, seeing that learning is nothing but a behaviour change, the question of how to achieve effective learning shifts to how conditioning is executed.

The most important type of conditioning in behaviourism is called *operant conditioning*. In operant conditioning, positive and negative reinforcement is used to reward or discourage a particular response in an animal or a person. This reinforcement usually translates to rewards such as reward points or praise to encourage good work and classroom behaviour in a classroom setting. While negative reinforcement can also be effective, for example by punishing students

by withdrawing privileges, positive reinforcement is widely regarded as the better approach.

Having learning be dependent on rewards does, however, come with some downsides. In a behaviourist system, students rely on extrinsic motivation – rewards from the outside – rather than the learning process being inherently satisfying and motivating. Behaviourist approaches have shown to decrease motivation among already motivated students [19]. There are situations where a behaviourist approach is appropriate, such as creating a safe and fast response to a dangerous situation or for students with whom no other method has been successful. That being said, behaviourism generally does not foster proper understanding but rather a correct response without knowing its reasoning.

6.2 Constructivism

Standing in stark contrast to behaviourism, constructivism strongly emphasises the mental processes behind learning rather than discounting them. Stemming from cognitive psychology, constructivism describes building understanding and learning. Compared to behaviourism, the differences are immediately apparent, with the two concepts focusing on entirely different processes when attempting to explain how learning takes place.

Adherents to constructivism believe that all learning happens through new concepts added to the brain's already existing knowledge structure. Therefore, all learning requires active participation by the learner, as their ability to connect new ideas to existing ones is crucial for understanding and retention in long-term memory. Conversely, behaviourism can be seen as a more passive form of learning where a learner only has to exercise the correct response while a teacher reinforces desired behaviour. Behaviourist learning depends on teachers to provide extrinsic motivation in the form of reward or punishment. Constructivism depends on the learner's inherent willingness to learn and intrinsic motivation – the teacher's role shifts from being the primary source of learning to one of facilitation. The goal is for students to learn through their processes. That can be accomplished by creating goals and objectives based on students' existing knowledge and providing support in the areas students have only partially mastered.

In an attempt to describe a person's knowledge and skill, cognitive psychologists use schema theory. In short, schema theory assigns each piece of information a *node*, be it a fact, physical sensation, or an idea. These nodes relate to each other through connections between nodes in a person's brain. Pritchard estimates that any adult has hundreds of thousands of these schemata, with many complex relations [19]. Learning, according to constructivism, consists of expanding

this structure by relating new concepts to already existing knowledge by creating ties between new and existing nodes. A vastly simplified example of schema pertaining to the idea of the ”video game box” is shown in Figure 6.1. The figure shows a few of the connections one might have to the idea of a video game box when applying schema theory. In reality, the node would have a much higher number of connections, and each of its connected nodes would have a similar number of connections to other nodes.

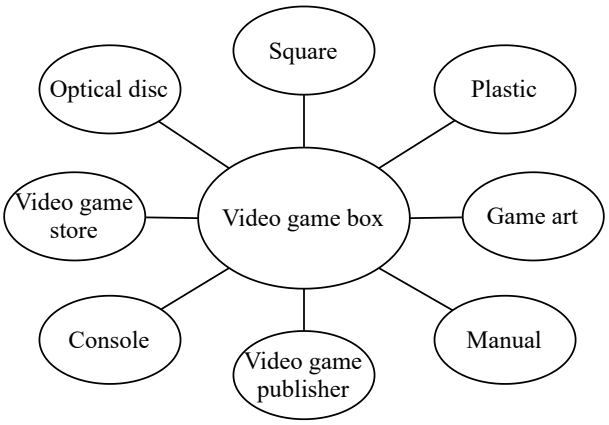


Figure 6.1: A simplified example of a schema for the ”video game box” concept

Early adherents to constructivism primarily viewed learning as a solitary process, which can only be supported to a certain degree by others. *Social constructivism* adds a new social dimension to the core of its theory. In social constructivism, it is believed that interaction with others is an excellent way to expand one’s knowledge. A key term in this field is the *zone of proximal development* (ZPD). The ZPD describes the next area of knowledge a learner will move into. It is an area where the learner can work effectively but only given proper support from someone sufficiently knowledgeable. This role could, for example, be filled by a teacher. The practice of supporting a learner operating in the ZPD is called *scaffolding*, and this is commonly accomplished through dialogue. However, Pritchard also mentions actions such as designing tasks to precisely fit someone’s knowledge level and providing a list of reminders regarding how to solve tasks as examples of scaffolding.

6.3 Summary

This chapter has summarised the two main branches of learning theory as they have been presented in Pritchard’s *Ways of Learning: Learning Theory and Learning Styles in the Classroom*. While behaviourism still has appropriate use-cases, it generally does not generate a deep understanding of a topic. On the other hand, constructivism focuses on the underlying mental

processes of learning and is usually better suited to achieving a proper understanding of a subject.

Chapter 7

The Jigsaw Method and Interdependence in Learning

In his now much-cited 1978 book, *The Jigsaw Classroom* [12], psychologist Elliot Aronson describes the method he and his graduate students invented and applied to help defuse racial tensions in recently desegregated Texas schools. Not only did this method, the jigsaw method, alleviate rising racial tensions and decrease the use of racial stereotypes, it even increased students' academic achievement. This method and its general goal (increasing task interdependence among learners) has since been the subject of numerous studies [23, 24, 25, 26]. It has consistently increased motivation and engagement among learners, with most studies also finding a significant increase in learning outcomes. This chapter will summarise the method and its effects. The concepts described here will be a vital part of the game design for this project's chosen game concept.

7.1 The Jigsaw Method

Aronson had a theory that much of the animosity experienced in classrooms was due to the competitiveness of the environment. He wanted to create a system that would force students to collaborate to solve their tasks. Together with his graduate students, he decided to distribute the information necessary to solve tasks among students so that no single student had all the pieces of the (jigsaw) puzzle, hence the method's name. In a "jigsaw classroom," students are placed in groups and have to rely entirely on other students to get a complete picture of the curriculum. Each student specialises only in the part assigned to them. The students then need to explain and discuss their allocated details with the rest of their jigsaw group, so all students eventually gain knowledge about each other's assigned curriculum. The jigsaw process is illustrated in Figure 7.1. Students in each *expert group* are given a piece of the curriculum, then moved to different groups (*jigsaw groups*) where they must communicate their piece to others.

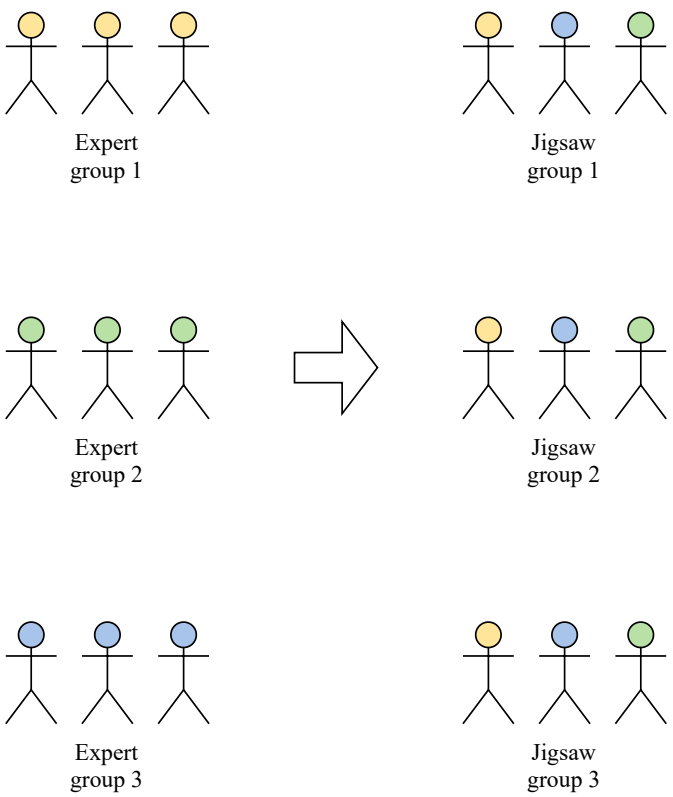


Figure 7.1: An example of how the jigsaw method can be applied

7.2 Interdependence and Heterogeneity in Learning Resources

The jigsaw method creates heterogeneity in learning resources among learners. The interdependence caused by this forces learners to communicate with each other, meaning that they have to participate in the learning process actively. Even learners who are unmotivated to learn for their own sake have a responsibility to help others, providing them with another source of motivation. We can draw parallels to the concepts covered in Chapter 6. As a lecture-based format where the teacher talks ”at” the students does not necessarily elicit any active learning on the part of the student, we can not consider this in line with constructivist learning theory. The same goes for task simple repetition, another common sight in the classroom pulled directly from the behaviourist playbook. However, the type of learning fostered by classrooms with a high degree of interdependence between students is the opposite. Each student is assigned a responsibility and needs to participate in active learning when researching their given piece, explaining it to their group, and discussing other topics.

There are, of course, also inconsistencies between increased interdependence and the constructivist model. An example is the extrinsic motivation applied through one’s responsibility to teach

others, while constructivism recommends relying on intrinsic motivation rather than extrinsic motivation. As a whole, though, compared to traditional lecture-based learning, the jigsaw method is more in line with the active learning proposed by constructivists. Thus it is not surprising that it generally leads to deeper understanding and better learning outcomes.

7.3 Summary

This chapter has outlined the history and effects of introducing increased task interdependence among students by examining Aronson's jigsaw method. We have drawn parallels with the learning theory introduced in Chapter 6 in a way that accentuates the advantages increased interdependence can provide. This chapter and Chapter 6 serve as the basis for our choices regarding the central mechanics of our game concept. We have shown that these mechanics do not only serve as a way to make the game more fun for players but possibly also increase its learning outcome.

Chapter 8

What Makes Things Fun to Learn?

Thomas W. Malone's article *What Makes Things Fun to Learn?* [27] explores guidelines for what makes a fun computer game. The article suggests that factors within three categories can define the essential properties of a fun computer game. As we are developing an educational game to make it educational and enjoyable for players, Malone's guidelines are relevant to our project.

8.1 Challenge

Challenges in games create purpose for the game and the player. A game without a challenge will quickly become boring. We can further break down the challenging aspect of a game into three critical factors.

Goal

A goal is the objective of the game. If the game is simple, the goal should be obvious. In more complex games, we should tailor goals to fit the player. Furthermore, goals should be practical or have a relation to some fantasy. This fantasy could, for example, be running to the finish line. Lastly, there should be a way to track progress by receiving performance feedback.

Uncertain outcome

Uncertainty is vital as most players will find a game boring if they are sure to win or lose from the start. To remedy this, Malone suggests multiple elements that can be added. *Variable difficulty level* is one that we can implement in numerous ways, for example, by automatically detecting the level of the player or the opponent's skill level or leaving it for the player to determine. Another element that adds uncertainty is *multiple level goals*, which is accomplished by adding a meta goal to a primary goal. For example, the main objective could be to run to the finish line, and a meta goal would be to collect coins. Adding *hidden information*, like in Hangman [28], will also increase uncertainty. Lastly, the simplest way to add uncertainty is to include *randomness*.

Self-esteem

"Goals and challenges are captivating because they engage a person's self-esteem" [27]. Malone argues that challenges can either increase or decrease a player's self-esteem. The way performance feedback is presented in a game is essential to minimising self-esteem damage.

8.2 Fantasy

Including fantasy in learning games makes it increasingly fun. Fantasy usually depends on the use of real-world skills and can further be split into two parts, *intrinsic* and *extrinsic*. The relation between these is shown in Figure 8.1 [27].

Intrinsic fantasy is where the fantasy depends on the skill, and skill also depends on the fantasy. This connection usually means that the problems are presented as elements of the fantasy world in a game. For example, imagine a bow shooting game where you want to hit balloons on a target. The skill of estimating distance applies to this fantasy world of balloons on a target. Players will also receive visual feedback on the result of a shot and determine how far away from the target the arrow went. Malone suggests that intrinsic fantasies are to be preferred.

Extrinsic fantasy is more binary. It only depends on whether or not the skill is used correctly. Using the example of a bow shooting game, this fantasy would only care about whether an arrow hit a balloon or not. However, factors like how close the arrow was to hitting or how fast it was can also affect extrinsic fantasies.

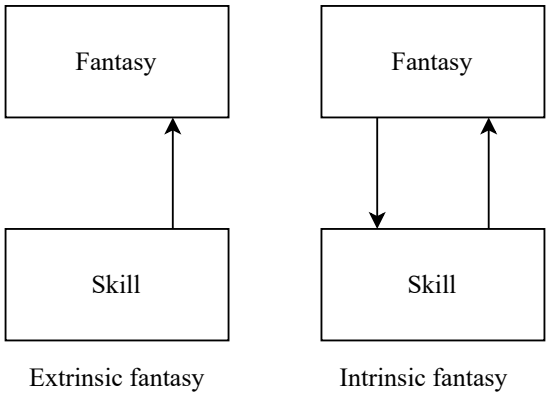


Figure 8.1: Logical dependencies in extrinsic and intrinsic fantasies

Fantasy in games can activate emotions in the player, which can increase engagement and appeal to the game. It is hard to satisfy all the emotional needs of the players. However, some

emotionally driven fantasies like war and competition are usually popular. These emotional aspects will highly depend on people, as everyone finds different elements appealing.

8.3 Curiosity

Curiosity increases motivation and is independent of goals and fantasy. Generally, a game should reveal enough complexity for players to get expectations without revealing too much. Curiosity can be divided between *sensory curiosity* and *cognitive curiosity*.

Sensory curiosity

Sensory curiosities are all changes or patterns in sensory stimuli of an environment. When games use audio and visual effects, it appeals to the player's sensory curiosity. We can use these effects in multiple scenarios. They can be used as *decoration*, which means that the game has sound and graphics that are "decorative", for example, in an intro view of a game. Another example for a scenario is using graphics or sound when trying *to enhance fantasy*. There are also scenarios where the game offers *rewards* to the player, using sound and graphics. Malone states that perhaps the best use of sound and graphics may be to use it as a *representation system*. The games can thus use sensory stimuli to represent other things like words or numbers effectively.

Cognitive curiosity

Cognitive curiosity is a craving to complete knowledge structures, which urges the players to fulfil their cognitive structure. Completing a cognitive structure is reminiscent of the intrinsic motivation described in constructivist learning (see Chapter 6). Another effect of this craving is the motivation caused by engaging players' cognitive curiosity. Players are more likely to want to learn if their existing knowledge seems to be inconsistent or incomplete. That is why murder mysteries are so intriguing. People often have a strong desire to find out who the culprit is and cannot just leave the book at the end.

8.4 Summary

This chapter presented a framework for identifying fun in learning games. A description and examples of three categories, challenge, fantasy, and curiosity, were detailed. Although all these properties are essential, Malone concludes that adding everything is hard. The best games focus

on specific features, and not all. Game developers must determine what their game should focus on. Designing and developing a fun game is essential for our learning game. How this theory is applied in our game is discussed in Chapter 20.

Chapter 9

GameFlow: Making a Fun Game

Sweetser and Wyeth's *GameFlow* [29] is a system of criteria used to evaluate how enjoyable video games are, being an adaptation of Csikszentmihalyi's theory of flow [30]. After collecting data regarding what makes experiences enjoyable for over a decade, Csikszentmihalyi arrived at eight elements that affect reaching a flow state. Achieving flow is often referred to as "being in the zone", a state of intense concentration and enjoyment during an activity. The GameFlow framework combines the eight elements of Csikszentmihalyi's flow theory and a final social element with traits of well-designed video games. The result is a framework that aims to provide designers with various criteria to focus on when creating an engaging game. Like in the original Flow theory, these criteria are divided into eight categories, with seven directly based on elements in Csikszentmihalyi's flow and the final one being social interaction, unique to GameFlow. Keeping these elements in mind is advantageous when creating an engaging and enjoyable game concept that lets players experience a flow state.

9.1 Concentration

Games should quickly grab the player's concentration and provide enough stimuli to keep the player's attention throughout the game. The game should require a high concentration level without overwhelming the player, which we can achieve by providing stimuli from different sources, especially those worth focusing on. Sweetser and Wyeth mention examples such as having a detailed game world and maximising the screen space taken by the game itself to increase the likelihood of the player becoming immersed in the game and concentrating on the game world rather than the outside world. Figure 9.1 shows a screenshot from a competitive online game *League of Legends* [31], which requires high concentration. Note how almost the entire game screen is used for the game itself with minimal user interface elements, creating plenty of space for visual stimuli.

Figure 9.1: Screenshot from League of Legends showing minimal interference from the UI

9.2 Challenge

The relationship between skill and challenge difficulty is crucial in the concept of flow. According to Sweetser and Wyeth, challenge is widely regarded as the most critical element for good game design. Like any other activity where one wants to achieve flow, a game must present challenges that push the player without becoming so difficult that the player cannot complete them. Additionally, the level of challenge should increase over time to keep pace with the player's increasing skill. A well-designed game also varies the difficulty and pacing to avoid exhausting the player. Finally, game difficulty should fit a wide range of players, for example, by letting the player change the game's difficulty setting or by having the game automatically adjust to the player's perceived skill level.

9.3 Player Skills

Closely related to the challenge element are player skills. This element relates to facilitating player skill development and aptly rewarding players for their increasing skill. Rather than reading a manual to understand how to play the game, players should be able to "pick it up and play" and gradually be taught game mechanics through in-game tutorials instead. In addition to tutorials, context-sensitive hints can be used to prevent players from getting stuck. As the player improves at the game, their rewards should also increase, encouraging the player to put

effort into continuous skill improvement.

9.4 Control

A player needs to feel like they control their actions to experience flow. This feeling largely stems from the game's controls and how the player's actions affect the game world. Games should have an intuitive control system that enables precise movement within the game world. A control system should comprise a basic set of main buttons, possibly expanding into more advanced controls once the player is ready. In addition to a solid set of in-game controls, the game shell should be easy to operate, and making errors in menus should be impossible for the player. The game should generally help the player understand and recover from mistakes, as they can otherwise take away the player's feeling of control.

9.5 Clear Goals

Games should have clear objectives or goals that the player can work towards. An overall purpose or goal should be presented at the beginning of the game, and intermediate goals should be given when fitting. Having something to work towards is important for the player to feel satisfied, and Sweetser and Wyeth suggest that games should present players with multiple goals for each game level.

9.6 Feedback

For players to remain concentrated over more extended periods, which is required to experience flow, they must receive immediate feedback on their actions. In addition to this, players should always be able to see their current status in the game and how well they are currently doing. The feedback that lets the player know how and when progress is made is critical if a player is struggling with the game, as this can help them correct their course before frustration sets in. Combat-oriented games like *Genshin Impact* often show damage numbers immediately upon hitting an enemy, providing instant feedback to the player, as seen in Figure 9.2. Additionally, health bars for the enemy (top of the screen) and the player (bottom of the screen) are visible during the fight, ensuring the player always knows how a fight is going.

Figure 9.2: Screenshot from Genshin Impact showing instant feedback in combat

9.7 Immersion

Sweetser and Wyeth point to the term *deep but effortless involvement* as the part of experiencing that relates to immersion in games. Games should pull the player in and make the player experience an altered sense of time. As Sweetser and Wyeth write, "Games should make players forget that they are participating through a medium so that the interface becomes invisible or unnoticed by the player" [29]. Audio is mentioned as necessary for creating and keeping immersion, and the game's narrative is vital for how involved and immersed the player becomes in the story of a game.

9.8 Social Interaction

Unlike the previous seven elements of GameFlow, social interaction is not connected with elements in Csikszentmihalyi's Flow model. Neither is it an element that contributes to flow or even to the game tasks themselves. Social interaction can often be detrimental to immersion and flow, but it is undeniable that social interaction can play a prominent role in game enjoyment. Rather than improving the tasks the game has players do, games can use tasks to facilitate social interaction, whether through cooperation, competition, or simply interaction with other players. Because of this, Sweetser and Wyeth argue that games should enable social communities inside and outside the game, as these can lead to a great deal of player enjoyment.

9.9 Summary

This chapter has summarised GameFlow, which Sweetser and Wyeth have proposed as a general criteria system for enjoyable video games. It bases itself on Csikszentmihalyi's theory of flow, which outlines eight elements that should be present in an experience for flow, an almost transcendent state of concentration, to occur. GameFlow comprises seven elements based on flow and the element of social interaction, resulting in eight elements that are often well-executed in enjoyable video games. This chapter has also given a brief description of each element. Being aware of which elements are most relevant to having players achieve a flow state will aid us in creating an engaging and enjoyable game as the project progresses.

Chapter 10

Game Reward Systems

There are many well-established forms of video game rewards, ranging from feedback messages to access to in-game content. Rewards in video games can improve both the player's enjoyment and motivation, making them highly relevant for all games, including educational ones. An article on the topic is included in this literature review to ensure our game utilises the potential of game rewards. Wang and Sun's *Game Reward Systems: Gaming Experiences and Social Meanings* [32] dives deep into the topic of video game reward systems, examining many sides of the issue. Most relevant to our project is their list of different forms of rewards, how rewards affect player motivation, and their considerations for reward system design. As such, only these elements are summarised here.

10.1 Forms of Video Game Rewards

Wang and Sun describe eight forms of video game reward systems, all described briefly in this section.

Score Systems

Scores are among the oldest types of video game rewards. They are numbers that represent a player's performance, usually without directly affecting the gameplay. Scores can either be specific to a game level or session, or long-term like rankings in competitive online games like *League of Legends* and *Starcraft 2*.

Experience Points and Levels

Experience points are a reward usually gained from performing certain activities, like combat, completing a puzzle, or performing a skill. They differ from scores by generally being tied to a character or avatar and usually making the player's character stronger. The score is often used to indicate skill, while experience is typically an indicator of how much time and effort has been put into a game. Hence high scores usually carry a higher social status than high experience, although this is certainly not always the case.

In-game Items

In-game items are effectively ubiquitous in RPGs, online or otherwise, and are common in recently emerged Battle Royale-style games, such as *PlayerUnknown's Battlegrounds (PUBG)* and *Fortnite*. Items often act as encouragement during otherwise duller periods of gameplay.

In-game Resources

Often used to improve a player's character or base, in-game resources differ from items in that items are usually more of an end goal. Players are more inclined to brag about an item than a resource obtained. Resources are common across all game genres but often seen in RTS games and RPGs. In MMORPGs like *Old School Runescape* [33], players quickly build up large numbers of in-game resources and items, for example, by killing monsters and completing quests. An example of such a collection can be seen in Figure 10.1.

Figure 10.1: In-game resources and in-game items in Old School Runescape

Achievement Systems

A mainstay in modern game platforms, achievements let players show off their skill or dedication to a game by completing difficult or time-consuming challenges stipulated by the achievement system. Having completed challenging achievements can provide high status in the game's community, and achievements should be visible to other players. Figure 10.2 shows an example of this, with game platforms like *Steam* usually have ways for players to show off their in-game achievements, such as the achievement showcase profile module depicted here.

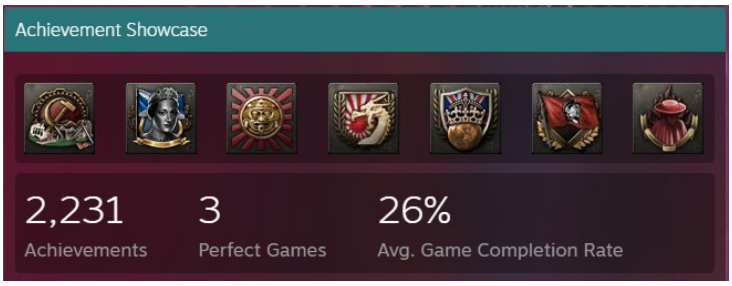


Figure 10.2: Achievement showcase module on the profile of a Steam user

Feedback Messages

Feedback messages are primarily a way of providing players with instant feedback to create a responsive and satisfying gameplay experience. They usually appear in the form of text, audio, image, video, or a combination of these and do not directly affect the gameplay. Feedback messages can be an essential part of the *Feedback* category of GameFlow (see Chapter 9).

Plot Animations and Images

During significant moments a game might show the player an animated cinematic or image, for example, depicting story events. This content can motivate the player to keep progressing through the game's plot and provides appealing visuals.

Access to New Features or Areas

Finally, a common form of reward is access to content previously inaccessible to the player. This access can be in the form of anything from a new mechanic to an entirely new area. As mentioned in Section 8.3, Malone stresses the need to keep certain parts of the game hidden to stimulate a player's curiosity [27]. Having entire areas be locked off until players reach a certain level is expected in MMORPGs. According to James Gee, gradually unlocking a game's content supports "ongoing learning" [34]. It is common for complex games to reveal game mechanics as part of their tutorial and even later in the game, to prevent players from being overwhelmed.

10.2 Rewards, Motivation and Parallels to Education

Keeping players motivated and interested in playing is vital in achieving sustained learning, making player motivation an important area of focus for us. Wang and Sun argue that well-designed reward systems can be a strong motivator, even when the player is not in the process

of receiving a reward. They point to the sense of anticipation created in the player, knowing they are about to receive worthwhile compensation for their efforts. Wang and Sun describe certain traits good reward systems should have, which we will summarise in the next section.

The same concept of instant feedback and reinforcement that makes video games feel responsive and satisfying is highly relevant in educational research. Wang and Sun imply that mechanisms that motivate large amounts of effort in video games might also see success in motivating effort towards academic achievement. They also mention that a ”game-like” reward system may help reduce pressure and fear of failure among students and that it can also provide alternatives to scores as measures of success. There are multiple intriguing elements of reward systems that can motivate players in a game and students in a course.

10.3 Game Reward System Considerations

To conclude their article, Wang and Sun propose some considerations for reward systems aimed at video game designers [32].

1. If the game's target audience includes casual players, rewards should be accessible even in short play sessions. The time investment often needed for hardcore games can prevent people from playing them.

2. Reward systems should not only provide rewards but also create fun and anticipation at the times players are not receiving rewards. Making subgoals for players to pursue is mentioned as an example of this.

3. Repeated throughout the article is the need for balance between time invested in an activity and the value of the reward gained from it. The longer players go without being rewarded, the higher their expectations become. If rewards are too easy to achieve, players risk losing their appreciation of good rewards, and previously achieved rewards might feel devalued.

4. The use of uncertainty in-game rewards creates fun for players but should not be used in certain situations. Rewards directly tied to player skill, such as their score, and rewards the player depends on for progressions, such as health and ammunition, should be predictable.

5. Rewards can be split into two primary categories regarding their effect and purpose; accumulated rewards and instant feedback. Accumulated dividends build up over time, like resources, scores, or items, and help the player feel a sense of progression throughout the

game. Instant feedback makes the game more responsive and satisfying and helps maintain flow.

6. Rewards often have a social purpose. Achievements and items, for example, can be shown off to and compared with other players and often help create a group identity among players who have achieved the same feats.

7. Mobile technology has enabled game-based reward systems in real-world activities, like chores and exercise.

10.4 Summary

This chapter has summarised Wang and Sun's article on video game reward systems, *Game Reward Systems: Gaming Experiences and Social Meanings*. The eight forms of video game rewards identified by Wang and Sun have been presented, followed by a reflection on how video game rewards affect motivation and how we can draw parallels to education. Finally, Wang and Sun's general considerations for video game reward systems, seven points that should be considered when designing rewards, have been listed. We intend to keep these considerations in mind when creating and developing a game concept in the later stages of this project.

Chapter 11

Learning by Design

"When we think of games, we think of fun. When we think of learning, we think of work" [35]. In James Paul Gee's article *Learning by Design: Good Video Games as Learning Machines*, he discusses the contrary. Learning does not need to be associated with work. What makes a good game deep and fun is the learning it triggers. Great game designers successfully apply methods to empower learning and cause players to enjoy it. Gee discusses principles, how games apply them (with examples), and what it implies for education. According to Gee, games that use these principles are more beneficial for learning.

11.1 Empowered Learners

Gee draws forth a few principles in games that empower learners. *Co-design* is one of these. In good video games, the players sense the feeling of co-creating the world. They are the ones that interact with the game and make things happen. Typical examples of such games are *The Elder Scrolls series*, open-world RPGs with a heavy focus on the story. The players get to decide what to do, and they can, for example, choose whether they want to explore the vast map or do quests. Figure 11.1 depicts an example of exploration in Elder Scrolls Online [36]. In education, co-design is about letting the students feel ownership in their learning. Interaction with the curriculum is essential for the motivation of students.

Figure 11.1: Exploration in Elder Scrolls Online

The following principle, *customise*, is about finding the style that works for each individual. There are mainly two ways of doing this in good learning games. The first is achieved by letting players customise aspects of the game themselves, while the second is done by the creators designing the game. Both serve the purpose of allowing different styles of learning and playing. In an educational context, customisation should enable students to find their preferred learning style and try new ones without being punished.

The next principle is about *identity*. There are many games where the player plays as a fictional character. Great games engage the player to trigger a deep investment in the character. In a way letting the player take on this new identity. Examples of this include games like *Red Dead Redemption 2* [37], *Animal Crossing* [38], and *Elder Scrolls V: Skyrim* [39]. Figure 11.2 shows an example of the playable identity in Red Dead Redemption 2. Most schools are built around a standardised checklist of teaching and testing. However, this will not engage every student. Gee believes that *"They need to know how to take on the identity of a certain sort of scientist, if they are doing science, and operate by a certain set of values, attitudes, and actions"*. Taking on a new identity is thus an engaging way of triggering deep investment in learning.

Figure 11.2: Arthur Morgan, the player character in Red Dead Redemption 2

The last principle in this category is about *manipulation and distributed knowledge*. Human perception deeply connects to action, according to cognitive research. In a lot of video games, the player can *manipulate* a character to move through the world. Good games extend this and allow players to manipulate objects of the game, which then become "smart tools". An example of this is *Tomb Raider* [40], an action-adventure game with a focus on exploration and puzzles. Figure 11.3 shows the main character Lara Croft. She can climb ropes, shoot arrows with a

bow, and scale walls. The player may not be able to do these things in real life but does so in the game by controlling the character. On the other hand, the player does need to integrate knowledge with the virtual character to succeed in the game. This integration is an example of *distributed knowledge*.

Figure 11.3: Lara Croft with a bow in the Shadow of the Tomb Raider

In school, ”smart tools” partly make learners manipulate the world. Gee gives an example of how Galileo discovered the laws of the pendulum not by playing around with the pendulums but because he applied his knowledge in geometry. It is still common for teachers to ask students to play with pendulums to discover the laws, though it is easier to understand by applying ”smart tools” such as geometry.

11.2 Problem Solving

There are some principles for problem-solving that are important. The first principle that Gee brings to attention is *well-ordered problems*. This principle regards learners' need to balance a complex and unorganised problem early on. Finding this right balance can help to better understand and solve later issues. Furthermore, good games follow this principle and guide the player to look forward to playing later parts of the game by having a well-thought-out initial part. The same can be applied to education as well. Having a too chaotic or complex learning environment is not satisfactory for learners.

The ensuing principle is about having learning be *pleasantly frustrating*. Learners should feel that they are being challenged and rewarded for their effort and see their progress. Good games solve this by giving challenges and feedback which fit the player. They get feedback on things they do well and things that did not go well. Figure 11.4 shows a boss fight in *Ratchet and*

Clank: Rift Apart [41], an action platformer series with a science fiction setting. In this game, beating or losing to a boss works as feedback on players' performance. In an educational context, this principle is often hard to follow. All students are not on the same level. A few may find some challenges too difficult, while others think it is easy. Ideally, the difficulty level and the corresponding feedback should be tailored to each student.

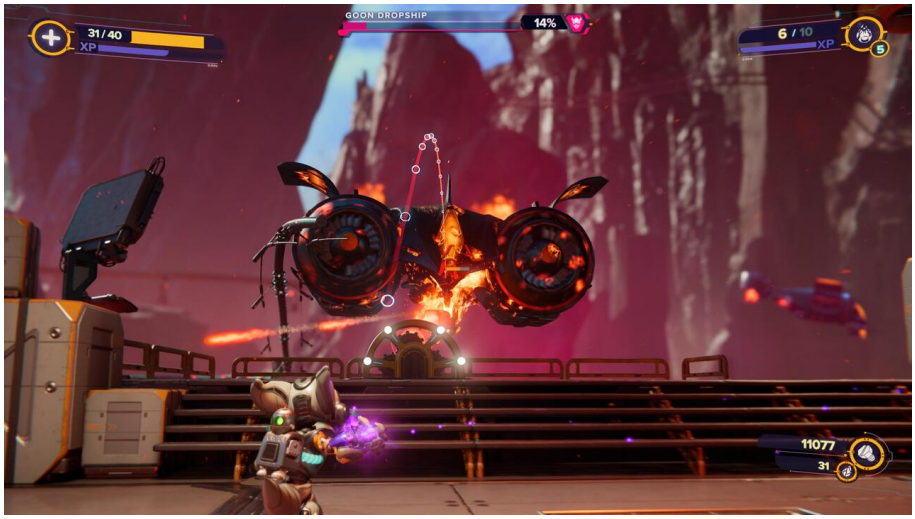


Figure 11.4: Fighting a boss in Ratchet and Clank: Rift Apart

Cycles of expertise is a principle about repetitiveness in learning turning into expertise. Doing a thing multiple times will gradually make a player better at it. Games support this by adding challenges and mastery achieved by fighting bosses and levelling up. Schools usually do not let learners experience expertise in the way games do. There is often not much focus on inspiring students to learn new things or gain a higher level of mastery.

The next principle is *information 'on demand' and 'just in time'*. Gee states that humans are poor at verbal information when given a lot of it out of context. Verbal information is best given when it is 'just in time' and 'on demand'. Games do this well by not requiring any manual before you play. However, players can refer to a manual on-demand later if they need more information. Schools often demand students sit through lectures and read lengthy materials. In the same way as a science book, game manuals do not make much sense reading without trying to play them first. Schools rarely give out information 'just in time' when needed, but rather 'on demand' when they think students are ready for it.

The following principle is about *fish tanks*. A fish tank can be considered a simplified system of a more extensive complex system like Newton's laws as a metaphor for learning. This simplified system can be a more accessible version of the same game, like tutorials at the start of a

playthrough. In education, students are often trying to learn a lot of complex systems without a way to build the knowledge needed to understand them well. People usually get help with tools, models, and theories to understand complex systems in the real world.

Following metaphors, the next principle is about *sandboxes*. In real life, sandboxes are safe places for children to experience and play with elements of the world. As a metaphor, sandboxes are about having a place to learn without much risk or danger. There are often sandbox options in good games in early levels or even standalone play. Figure 11.5 shows an example of *Planet Zoo* [42], a zoo construction and management simulation game. In this game, the player has the option to play a sandbox mode to receive infinite sums of money they can play around with. A big problem in schools is that taking risks by learning new things or trying new hypotheses out of the curriculum often feels too risky and punishing.

Figure 11.5: Sandbox mode in Planet Zoo

The last principle is about *skills as strategies*. People want to learn things when they see that it is directly helpful for a goal they want to accomplish. They do not enjoy learning something out of context. Good games utilise this by making you use the skills you learn to reach goals throughout the game. In games like *Metal Gear Solid* [43] and *Call of Duty* [44], training exercises are great for learning skills you get to use later. However, in school, this is not always apparent. Students often feel that they learn things that may have no use.

11.3 Understanding

To understand education, Gee draws attention to two principles. The first one *system thinking*, is about seeing the big picture. People are more likely to learn new skills and ideas to see how

they can fit into a more extensive, meaningful system. Games are good when they help the players understand how the more minor elements fit into, the bigger picture. Figure 11.6 depicts an example from *Call of Duty*. In this game, players can play through smaller training exercises to better understand the environment and develop good intuitions about the complex system. In an educational context, many things students learn will become useless if they cannot see how each minor isolated element is connected to complex systems and relationships. It will lead to a sub-par understanding of the material as they cannot apply what they learn.

Figure 11.6: Training exercise in Call of Duty Warzone

The last principle, *meaning as action image*, refers to thinking through experiences. Most humans tend to associate meanings of words with experiences rather than definitions and logical principles. When people think of travelling, for instance, the sense is often carried by their own experiences rather than the definition of what travelling is. Most games do this well by having the player interact and experience the game rather than having presentations about definitions and concepts. For example, games in a historical context let the player interact with events like the Normandy Invasion rather than presenting them. In school, students will have a hard time if treated like dictionaries. Humans are not built around being fed a lot of information without conceptualising models in their heads.

11.4 Summary

Empowered learners, problem-solving, and understanding are essential topics in learning in games. This chapter presents multiple principles within these topics used in games, compared to how it is in school. Learning in school does not need to be associated with monotonous work.

An important step to remedy this connection is understanding the principles presented in this chapter. Applying these principles to the development of game concepts will be helpful later.

Chapter 12

The LEAGUE Framework

To address the gap in the literature pertaining to a standardised framework for the evaluation of games that implement Game-Based Learning (GBL), Tahir and Wang used existing literature on GBL evaluation to create a general framework [45]. In addition to providing a basis for evaluation, it serves as a sort of checklist for essential aspects of GBL applications. The framework, *LEAGUE*, is comprised of six dimensions, each represented by a letter in the framework's name. While we are not currently planning on thoroughly evaluating our GBL application, the use of LEAGUE as a list of focus points will help guide our game concept towards a better implementation of GBL. Due to this, we will not cover LEAGUE in-depth here, but we will give a general overview.

12.1 Structure and Use in Our Project

As previously mentioned, the LEAGUE framework comprises six dimensions.

- **Learning**: Aspects of a game directly regarding learning, such as the educational content, the desired outcome, and the pedagogical strategies employed along the way.
- **Environment**: The technical and physical context of a player playing a GBL game. This dimension covers technology-related issues.
- **Affective Cognitive Reaction**s: Relating to the reactions, often emotional, which the game triggers in players. Includes aspects such as immersion and Csikszentmihalyi's flow [30].
- **Game Factors**: Aspects of the game relating to the game itself, such as mechanics, narrative and gameplay.
- **Usability**: How easily understandable and playable the game is, both with regards to its interface and how it teaches players the functions available.
- **usEr**: The characteristics of the intended audience which should be considered in the game's design.

These represent a critical GBL aspect and are categorised into domain-specific and generic dimensions. Domain-specific dimensions relate directly to core GBL concepts, while generic dimensions support GBL concepts and are essential in any software application. Dimensions are divided into multiple factors, with 22 factors across all six dimensions. Most factors can be broken down into sub-factors, which are supposed to be evaluated using five types of metrics and were introduced to relevant factors to aid objective evaluation. We will use factors as areas of focus regarding our game concept, with sub-factors providing specific pointers. The entire LEAGUE hierarchy, with all associated factors and sub-factors, is shown in Figure 12.1 [45].

Figure 12.1: The full LEAGUE hierarchy

12.2 Summary

There has been a lack of a standardised framework that we can use to evaluate games that implement GBL. Following a literature study, Tahir and Wang created the LEAGUE framework following a literature study presented in this chapter. The LEAGUE framework consists of six dimensions, each with several factors and sub-factors. While described as a framework for evaluation, Tahir and Wang clarify that it can also be used as a checklist for important factors in GBL, which is our intended use in this project.

Chapter 13

Model for Classification of Learning Games

As the project's research goal includes creating a collaborative learning game, it is crucial to understand what classifies a learning game. In this and the next chapter, we will look at existing relevant games. It will be easier to evaluate the games' properties and their respective strengths and weaknesses with proper classification. Additionally, we will use these properties as inspiration to create new game concepts.

While some of the researched games described in this project are not necessarily collaborative learning games, they all share characteristics relevant to game concepts created in this project.

13.1 Classification

This section will focus on six game characteristics relevant to this project. We will present these characteristics with examples of games where it is applicable. It is important to note that we chose these characteristics to gain a valuable overview of games for a more straightforward evaluation afterwards. There will therefore exist other characteristics which are not taken into account here.

13.1.1 Game Types

Games are not limited to one medium. Games can be of a multitude of types. Lomax's chapter in *Handbook of Sports and Media* [46], the history of fantasy sports illustrates this. Before computers, people played fantasy sports as game types such as board games, card games, and dice games according to set rules. For example, one game type could be a card game, where players pitted baseball player cards up against and rolled a dice to determine the outcome of the pitcher versus the batter. As computers eventually came into play, other game types such as browser games, computer games, and mobile games emerged.

Drawing a parallel to games, as technology evolves, it opens up possibilities to create new game types. Modern examples include pervasive games and Virtual Reality (VR) games. These are game types that use technology to fuse reality and video games.

13.1.2 Game Genre

Prensky states that games are generally recognised within these eight genres: Action Games, Adventure Games, Fighting Games, Puzzle Games, Role-Playing Games (RPGs), Simulation Games, Sports Games, and Strategy Games [47].

These main genres also include sub-genres. For example, a game like *World of Warcraft* is often categorised as a Massively Multiplayer Online Role-Playing Game (MMORPG), which is a sub-genre within RPGs [48]. A game can also consist of multiple genres.

It is important to note that this project distinguishes between game *type* and game *genre*, while they are sometimes used interchangeably elsewhere. The game type describes the medium related to what the game is being played on, for example, board games, card games, and pervasive games. Game genres, however, describe such games' gameplay, which is listed above. A game will thus have both a type and a genre. An example is *Knowledge War*, a learning game that implements geolocation features and quiz battles [49]. The game type is a pervasive game as the game uses location, so the students have to move around campus to compete. The game genre is role-playing as the game utilises elements from the genre like building and growing a character.

13.1.3 Target Group

Games determine a target group to appeal to the intended users they want to play their game. Learning games usually target people in education, such as students and teachers. However, learning is broad and can appeal to all target groups. Prensky observes a positive correlation between learning and playing, where a children's favourite, Sesame Street, is used as an example of the beneficial effects of enhancing knowledge through play [47]. He then states that adults also play, even at work. Many scientists think of their work as play, and even in modern workplaces, there are leisure activities such as miniature golf courses where they can play. Thus, playing games in a working environment can enhance learning by reducing stress and increasing productivity. The target group for learning games can therefore be more than only students.

13.1.4 Interaction Between Players

In games, there are multiple ways of interacting between players. Many popular games are digital, with the interaction happening in the video game. In contrast, many children grow up playing games where all the interaction is in real life, like a game of tag. We will, in this

characteristic, make the distinction of a game being interactable out of game or in-game. For out of game interaction, players are expected to affect gameplay by interacting with other players aside from the game. For example, this interaction can be through voice communications, whether players communicate through a digital call or in real life. On the other hand, an in-game interaction expects players to affect the gameplay by primarily interacting with the game through clicking, swiping, or touching a screen.

Interaction between players can also be of different types, like cooperative or competitive. In cooperative games, players work together to solve a common goal, like in a game of *Overcooked* [50]. Overcooked is a game where users play as chefs to prepare meals and avoid obstacles rapidly. In competitive games, players are pitted up against each other, like in a game of Chess. Many games combine the two, for example, in League of Legends [31], a Multiplayer Online Battle Arena (MOBA) game. In this game, players are divided into two teams of five champions and cooperate to compete against each other to destroy the enemy's base.

13.1.5 Learning Effect

As video games continue to increase in cultural relevance, a rise in learning games is apparent. Many video games exist solely for educational purposes, like Kahoot!. However, many games are not created for learning but instead have learning as a sub-effect. Minecraft is a great example, as the game was initially created as a fun survival and exploration game. Many have since observed the educational value of the game [51, 52, 53]. An educational version of the game, designed for schools, was released in 2016 [54].

13.1.6 Learning Field

Schools have education plans for what children will learn throughout their time there. These plans result in students studying various subjects ranging from language to STEM subjects. For educational video games, it is possible to differentiate between the fields for which they are intended. For example, Dragon Box is a series of games made for learning maths. In a broader sense, games can also be made for every subject, like Kahoot!. The users supply the content in these games, making the games more versatile.

13.2 The Classification Model

We have created a model for comparing different games based on all the given characteristics and evaluation criteria. Table 13.1 is an example of a model for comparing three games. If

a game fits inside one or more of the characteristics, the cell has a cross. As an example of assessing the table, ”game 1” will be used. This game has been marked as a board game and is in the adventure genre, targeted at university students and workers. Furthermore, the player interaction focuses on being in real life and collaborative. The game itself is not created for learning, but it can be argued to be more of a side effect. In that case, the learning would fall under the subject of geography. By defining these characteristics, we can compare factors between games and assess the strengths and weaknesses of each characteristic. Additionally, mapping out the elements is significant in determining the importance of each element when creating our game concepts.

		Games		
		Game 1	Game 2	Game 3
Game Types	Browser game	x		
	Mobile game		x	
	Card game			x
	Pervasive game		x	
Game Genre	Action		x	
	Adventure	x		x
	Etc..			
Target Group	Secondary school students		x	
	University students	x		
	Workers	x		
	Other		x	
Interaction	Out of game	x		
	In-game		x	x
	Collaborative	x		
	Competitive			x
	Mix		x	
Learning Effect	Primary effect			
	Secondary effect		x	x
	No significant effect	x		
Learning Field	All			
	History		x	x
	Geography	x		
	Math			x
	Other		x	

Table 13.1: Example of a model for classification

13.3 Summary

This chapter highlighted six game characteristics relevant to collaborative learning games, including a description with appropriate examples. Additionally, we introduced a model for comparing different games with an example of how to use them. The next chapter will present a list of existing games describing state of the art and being an inspiration source for creating our concepts.

Chapter 14

Educational and Collaborative Games

This chapter will present a selection of educational and collaborative games. While they might seem like a random choice of games at first glance, they are all highly relevant due to their interesting collaborative elements, educational elements, or both. At the end of each game's section, we explain why the game is relevant to our project.

14.1 Keep Talking and Nobody Explodes

Keep Talking and Nobody Explodes [13] is an asymmetrical multi-role collaborative puzzle game where the goal is to defuse a bomb by solving multiple puzzle modules, as seen in Figure 14.1. The asymmetrical aspect of the game comes from the game's primary unique feature; one person sees and controls only the bomb, and one or more people only see the manual [55], which explains how to solve the bomb [56]. This division forces the two parties to talk to each other to solve the puzzles. Additionally, to add a sense of urgency to the situation, the bomb has a relatively short count-down timer (usually 3-10 minutes, but this depends on the number of puzzle modules on the bomb). By the time the count-down completes, the players need to have defused it for it not to explode. The combination of time pressure and being forced to communicate due to all players having incomplete information makes for a fun, albeit stressful, experience. Additionally, this forces players to get on with the task at hand, possibly skipping some of the initial awkwardness that can be felt among players who are not particularly used to playing collaborative games.

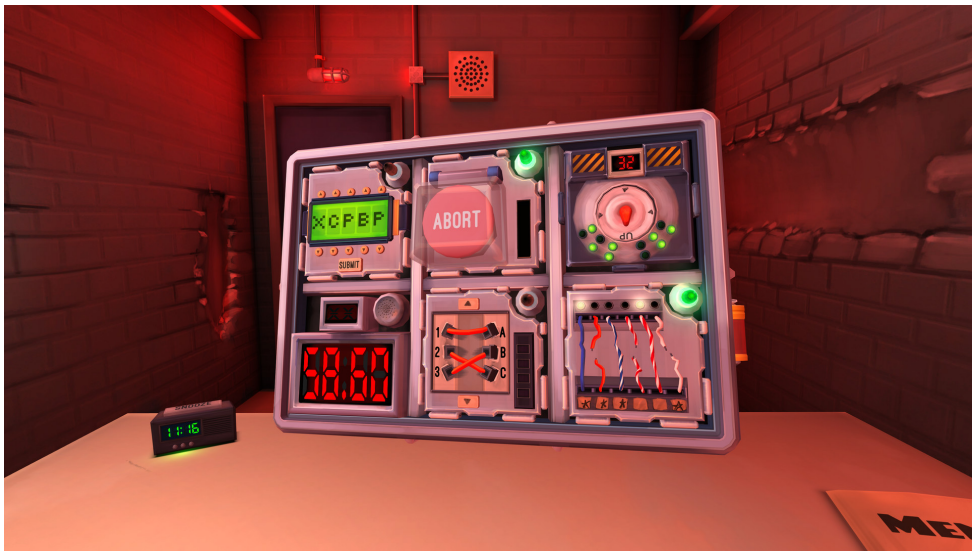
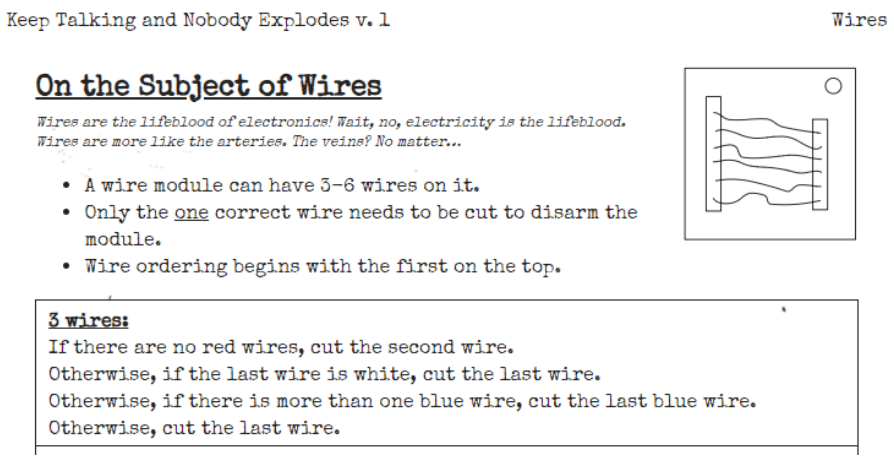


Figure 14.1: A bomb with five puzzle modules and a count-down timer in Keep Talking and Nobody Explodes

The game lets players print out the bomb defusal manual, which is stylised to look like a secret military document (as seen in Figure 14.2) [55]. While the player defusing the bomb now can play on both mobile and desktop platforms, the game was initially VR-only. Having one party using a VR headset and the other a stylised, physical manual increases immersion and, therefore, tension.


Keep Talking and Nobody Explodes v. 1 Wires

On the Subject of Wires

Wires are the lifeblood of electronics! Wait, no, electricity is the lifeblood. Wires are more like the arteries. The veins? No matter...

- A wire module can have 3-6 wires on it.
- Only the one correct wire needs to be cut to disarm the module.
- Wire ordering begins with the first on the top.

3 wires:
If there are no red wires, cut the second wire.
Otherwise, if the last wire is white, cut the last wire.
Otherwise, if there is more than one blue wire, cut the last blue wire.
Otherwise, cut the last wire.

Figure 14.2: The bomb defusal manual for Keep Talking and Nobody Explodes

Keep Talking and Nobody Explodes is an excellent example of how high task interdependence between players necessitates communication and fosters engagement.

14.2 GeoGuessr

GeoGuessr [57] is a browser-based puzzle game where the player is placed in a random Google Street View [58] location and needs to guess where in the world they are located, based on their surroundings. The player is then given a score based on how close their chosen location is to their actual street view location. While Google Street View would usually provide names of roads, cities and countries in the user interface, none of this is displayed in GeoGuessr, as seen in Figure 14.3.

Figure 14.3: A typical round of GeoGuessr

GeoGuessr forces players to use identifiers such as the terrain, language, signage and people around them to determine their location. The game has a dedicated fan base, and there are communities, such as GeoTips [59], that have extensive data banks of identifying characteristics for all countries available in Street View. While it would go against the spirit of the game, a player could use these data banks as reference material while playing, similarly to the solution manual in Keep Talking and Nobody Explodes. GeoGuessr can place players anywhere in the entire world in its standard game mode, but multiple new maps and game modes have been released. These new additions make small changes to the formula, such as not allowing players to move along roads or only placing the player in a certain country. Some modes even change the formula more drastically, like in the ”Battle Royale” mode, where ten players battle to not be the last person to guess which country they are all in.

GeoGuessr is an excellent example of how a game not initially designed as a learning game can still have an educational effect. Its core gameplay loop of being placed in an unfamiliar place

and deducting one's location from clues in the area uses players' curiosity as motivation, as described by constructivist learning principles (see Chapter 6).

14.3 Kahoot!

Kahoot! [60] is a gamified learning platform that lets users create and host quizzes, or "kahoots", for a large audience. A host can open a room that players can join with their own devices using the room's ID. A kahoot consists of multiple questions, with the most common question type being multiple choice among four possible answers, as seen in figure Figure 14.4. Kahoot! also supports other question types, such as free-write answers and a drag-and-drop reordering of answers. When every player has answered the question, the correct answer is revealed, and players are shown whether they chose the correct answer.

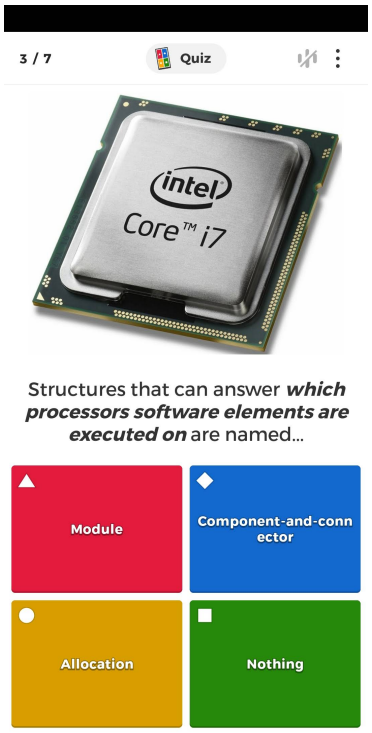


Figure 14.4: A question in Kahoot!

The platform is commonly used in classes and lectures to assess the degree of understanding among students or provide a break from traditional teaching activities. Kahoot! has been shown to positively affect the learning outcome and motivation of students [61, 62]. It has also been shown to improve classroom dynamics by making students less anxious to answer questions and more open to discussion with the teacher and other students.

Kahoot! is one of the world's most successful learning game platforms and is ubiquitous in classrooms worldwide. This fact alone makes it relevant for our project. Additionally, research into the effect of Kahoot! and how certain facets of the game affect learning, engagement, motivation and classroom dynamics are noteworthy to consider as we progress in our project.

14.4 It Takes Two

It Takes Two [63] is a multi-role action-adventure game with platform- and puzzle game elements. The game's story revolves around two parents, about to have a divorce, being turned into living versions of their child's dolls and having to traverse a fantasy version of their home. The game's narrative revolves around the two parents rediscovering, among other things, how to collaborate and communicate. It Takes Two is played entirely in split-screen mode, with both players' perspectives shown simultaneously, even during online remote play. This uncommon design choice was likely to emphasise and facilitate collaboration between players. The two players have different abilities and roles at almost every level, making good collaboration and communication necessary. Figure 14.5 shows an example of the game's split-screen and multi-role co-op, with one player can launch tree sap while the other launches lit matches - combining in a powerful explosion.

Figure 14.5: Split-screen gameplay from It Takes Two

Although generally a very different game from Keep Talking and Nobody Explodes, It Takes Two again accentuates the effect of high task interdependence on the gameplay experience. The need to fill various roles in the game's numerous puzzles ensures players communicate and provide the game with an additional exciting challenge.

14.5 Woodment

Woodment was a web-based collaborative learning game designed to be adaptable to any learning topic [64]. In Woodment, players control a customisable character from a third-person perspective in a 3D game world, as shown in Figure 14.6. This screenshot also labels various parts of the UI and was taken from the paper detailing the game's creation as it was the only high-resolution screenshot available. The game consists of two teams competing against each other, with three people on each team. Each team manages a logging company on the team's island, and they compete with the other team to be the first to chop down all the trees available on the island. Players choose between three roles, Risk Manager, Human Resources Manager, and Procurement Manager. These must be filled, and one person can only serve one role. Each role presents a different set of tasks for managing the team's logging company.

Figure 14.6: Screenshot of Woodment with UI labels

The learning aspect of Woodment is implemented through multiple choice questions available in specific locations around the island. A player can interact with a "Multiple-Choice Platform" to open a multiple choice question (see Figure 14.6), which can be answered by one or more players in the team. The team is then provided with resources if answered correctly. The content of these questions was managed through an online platform. They could be changed based on which learning topic the game was to be used for. This idea is similar to other online quiz-based learning

games, such as Kahoot!. However, the fact remains that Woodment's gameplay would always revolve around the management of a logging company, regardless of which topics the custom questions would cover. The upside was that the game was usable for any topic. The downside was the jarring disconnect between the gameplay and the theme of the questions. Woodment was effectively a multiplayer game and a quiz game combined, without much consideration for thematic integration between the two.

There are very few games that are collaborative learning games by design. Woodment, however, belongs in this category. Examining the successes and failings of this game is important when moving to design another game in the same field.

14.6 Summary

This section has presented a relatively varied set of existing games. In the following chapter, these games are organised to illustrate how the different games can serve as inspiration for various features or design directions. All the games in this section were chosen due to their relevance to our game concept. Keep Talking and Nobody Explodes and It Takes Two are good examples of collaborative games where high task interdependence between players is beneficial for the cooperative experience. While GeoGuessr is not an educational game by design, the gameplay encourages players to learn about geography, architecture, language, and flora worldwide. Kahoot! and Woodment are educational games by design. Kahoot! is a wildly successful hit that provides insight into classroom dynamics due to game design choices. Woodment is one of few examples of educational games based entirely on collaborative gameplay with competitive intergroup elements.

Chapter 15

Comparison of Existing Games

This chapter will compare the educational and collaborative games presented in Chapter 14 structured by the comparison framework described in Chapter 13. Table 15.1 shows the full complete classification of all five games from Chapter 14. It is immediately evident that the selection of games is very diverse regarding some characteristics while being more uniform regarding others. We will hereunder discuss each characteristic further in-depth.

15.1 Game Type

As seen in Table 15.1, we have chosen games of various types. As there were no requirements regarding how our game would be played, looking at a wide variety of games is sensible. One aspect to note is that all the games to which we attribute a significant learning effect to in Section 15.5 are playable in the browser. This finding might imply that games with learning effects aim to be as easily accessible as possible at the expense of graphical capability. These are among the primary positive and negative aspects of browser-based games.

15.2 Game Genre

While most of the games examined in Chapter 14 could be categorised as multiple game genres (It Takes Two could be described as an action-adventure platformer with puzzle elements), we have chosen only to mark the most important genres. Immediately noticeable is the presence of multiple puzzle games. Because we are looking primarily at games that possess some learning effect or emphasise collaborative problem-solving, this is no surprise, as puzzles generally fit both of these purposes. It indicates that designing a game in the puzzle genre or with puzzle elements will make it easier to successfully introduce collaborative problem solving and a learning effect in our chosen game concept.

15.3 Target Group

There is a clear split between games designed primarily as learning games and the rest regarding the target group characteristic. The two games designed with game-based learning in mind primarily targeted students. While not the case for every new concept described in Chapter 17,

most of our new concepts also target upper secondary school and university education. We should also mention that Kahoot! has become ubiquitous in everything from primary schools to workplaces in the last few years. We have, however, chosen to categorise it according to its primary audience when it was released. This audience was classroom environments at a time when smart devices were not yet universal in primary education, i.e. students in upper secondary school and university education.

15.4 Interaction Between Players

When examining how players interact in the games we have reviewed, it becomes clear that there is a significant majority among games where in-game inter-player interaction is digital rather than physical. One could argue that games like Kahoot! have a degree of physical interaction. We would argue that this interaction does not usually directly concern gameplay but rather concerns *the status of the game*, for example, the result of a particular question. Therefore, Keep Talking and Nobody Explodes is the primary inspiration for the real-life player interactions discussed later in this project.

15.5 Learning Effect

The games examined in Chapter 14 were chosen for various reasons, not only for their learning effect. This selection is evident when looking at the learning effect characteristic of Table 15.1. One game has only a secondary learning effect, and two games have no significant learning effect. While inspiration with regards to learning effect can be taken from Kahoot!, GeoGuessr and Woodment, this is not the case for It Takes Two and Keep Talking and Nobody Explodes. These games have been included for their implementation of collaborative mechanics, which is also a primary concern for our project.

15.6 Learning Field

Notable in the learning field characteristic is the distinction between games that can be utilised for learning in any field (namely Kahoot! and Woodment in our case) and inflexible games (GeoGuessr). While not an issue in Kahoot!, Woodment suffers from a possible disconnect between the game's quiz aspect and the rest of its gameplay. Whereas the quiz element could be utilised for learning in any field, the remainder of the gameplay would stay the same, causing a thematic disconnect between the two. Kahoot! solves this problem by not applying field-

specific gameplay elements to the game. GeoGuessr and other games like solve this issue by not being used for learning fields other than the game's theme. When creating a learning game, we consider it crucial to ensure it is universal enough in every aspect of gameplay to be used for any field *or* to restrict it to specific learning fields only.

Existing Games						
		Keep Talking and Nobody Explodes	**GeoGuessr**	**Kahoot!**	**It Takes Two**	**Woodment**
Game Type	Browser		x	x		x
	Mobile game	x	x	x		
	Desktop game	x			x	
	Console game	x			x	
	VR game	x				
Game Genre	Puzzle	x	x	x		
	Adventure				x	
	Simulation					x
Target Group	Secondary school students			x		x
	University students			x		x
	General population	x	x		x	
Interaction	Out of game	x				
	In-game		x	x	x	x
	Collaborative	x			x	x
	Competitive		x	x		x
Learning Effect	Primary effect			x		x
	Secondary effect		x			
	No significant effect	x			x	
Learning Field	Any			x		x
	Geography		x			
	Not applicable	x			x	

Table 15.1: Comparing various elements of existing games presented in Chapter 14

15.7 Summary

This chapter has compared the educational and collaborative games presented in Chapter 14 and concluded with multiple important factors moving forward to the concept generation stage. While the games chosen and examined might seem eclectic at first glance, they all serve a purpose

regarding our chosen design. The variety of games explored provides a similarly wide range of insight, especially concerning implementing successful educational and collaborative elements in games.

Chapter 16

Enabling Technology

This chapter describes technologies relevant to game development. Researching these technologies will be helpful when developing our concept. There are various technologies today that can be used for game development. These technologies will vary depending on the platform. Covering everything is out of scope for this project.

16.1 Game Development Platforms

Choosing a platform for the game is crucial as it heavily determines which technologies will be suitable. As the research goal is related to a collaborative educational setting, the platform of choice should be accessible to students. This condition means that some platforms, such as proprietary consoles and VR headsets, will not be included. In terms of accessible devices, most devices on the market today are either mobile, desktop, or tablet devices. Furthermore, the market share is heavily favouring mobile and desktop devices [65]. Additionally in Chapter 15, we noticed the games we attributed a significant learning effect to were all playable in the browser.

For smartphones, the market share of operating systems consists predominantly of Android and iOS [66]. It is thus beneficial to cover these operating systems when developing for mobile. Similarly, for desktops, Windows dominates, followed by Mac OS [67].

There are different ways of developing applications for smartphones and desktops. One solution is to create *native apps* for each operating system. If the target platform is mobile, another popular solution is to utilise a *cross-platform framework*. A versatile option is to create a *responsive web application* or a *Progressive Web App (PWA)*, which can be accessed from all platforms.

16.2 Tool for Visual Design

Design and prototyping tools are needed to envision how the game should look and feel appropriately. The tools we choose would also need to support collaboration in some form for us to work on the same design. If the game is web-based and needs wireframes, popular options for such tools are Figma and Adobe XD. Furthermore, for creating game elements, like avatars,

software like Photoshop or Illustrator from Adobe could be helpful.

16.2.1 Native Solution

Native apps are based on different programming languages. For instance, developers often use Java or Kotlin for Android development and Swift or Objective-C for iOS development for mobile apps. This difference means that developers will have to create and maintain two separate apps to cater for both audiences. This necessity is a significant disadvantage, especially for smaller development teams. Another flaw is downloading the application from a centralised store, for example, Google Play Store for Android devices or App Store for iOS devices. Publishing applications to stores takes time for review and deployment.

On the other side, native app development comes with many advantages. It adds the possibility for offline use and access to functionalities such as a camera, GPS, and microphone. Native apps are also more mature. Provided tools and resources are well documented and tested. Another great strength of a native app is better performance as it is better optimised for its device [68].

16.2.2 Cross-Platform Mobile Solution

Multiple frameworks are available for creating a cross-platform mobile app, each with strengths and weaknesses. The main strength of a cross-platform solution is having one shared codebase for both Android and iOS development. Additionally, such frameworks usually support other programming languages than native apps. React Native, for instance, uses JavaScript and a particular markup language called JSX. As JavaScript is widely used, this results in more versatility for developers who may not be familiar with the programming languages of native apps. This option is suitable if the game is mobile-based.

Cross-platform solutions also include game-focused frameworks. The two most famous examples of such frameworks are Unity and Unreal Engine. AAA games, i.e. games from major publishers, often use game engines like these [69]. These are designed to simplify complex visuals and game elements such as physics. They are also great for making more complex games with 3D graphics. However, these frameworks can become redundant when working with graphically simple games.

16.2.3 Web Solution

For graphically simple games, a web solution is a great option. Every platform supports browsing web pages, whether a player is on a desktop or a phone. This fact makes a web solution

highly versatile. The majority and the most popular web solutions depend on JavaScript as a programming language [70]. In modern web development, there are a lot of JavaScript libraries and frameworks to simplify the complexity of web apps. Prevalent examples include React, Vue, and Angular. There are also other options, such as Django, where Python is used as a programming language.

An essential factor in making a web game accessible on multiple platforms is responsive web design. This approach aims to render web pages similarly across various devices with different screen sizes. This element essentially results in an all-platform solution. Making a responsive web game is thus an excellent option for games that appeal to mobile and desktop players with significantly less cost than native solutions.

One major flaw with a web solution on smartphones is the lack of access to functionalities such as offline access, camera, and GPS. However, this flaw can be remedied by developing a Progressive Web App. A PWA also makes it possible to make a website installable on the phone as an app [71]. Utilising a web solution that is both responsive and a PWA adds a lot of versatility in being accessible on all platforms.

16.2.4 Choosing Between Native, Cross-Platform Mobile, and a Web Solution

The choice of which approach to use when developing a game is highly dependent on the situation. If the game is to be played on mobile, with support for both Android and iOS, a native solution is time-consuming as it requires a lot of development effort. A cross-platform or a web solution would be more suitable. However, if the game is focused on being accessible on both mobile and desktop, a cross-platform mobile app would require a different desktop version. A web game or a game-focused solution would then become better options. If the game is graphical intense with 3D elements, a game-focused framework should be preferred. Otherwise, a web solution is more straightforward.

16.3 Backend Solutions

Managing and storing data is necessary to implement a collaborative game with online interaction. There are many options to choose from when choosing a data solution. Writing a custom backend to handle a data source is an option. However, with the rise of cloud services, a more popular approach is to use Backend as a Service (BaaS). BaaS, in brief, provides a convenient

abstraction from a custom backend solution. Today, BaaS is offered by all the major cloud providers such as Google, Amazon, and Microsoft.

16.3.1 Backend as a Service

Using a BaaS solution has a lot of advantages. It comes ready to use, enabling the developers to have a quick and effective development process. The developers do not need to spend a lot of effort developing and maintaining a custom backend. BaaS are also highly scalable and feature-packed and can handle everything from storage, hosting, and authentication. However, the main disadvantage is less flexibility since developers must follow standardised solutions. Popular BaaS examples include Google Firebase, AWS Amplify, and Azure Mobile Apps.

16.3.2 Custom Backend

Developing a custom backend is a standard solution and offers a more flexible solution customised to fit the need of the application. A significant advantage is a more straightforward process of integrating existing systems into the custom backend if needed. However, the backend has to be created from scratch. Developers will have to plan, develop, and maintain the application's infrastructure, which increases the time and effort needed.

Popular backend technologies include Django, NodeJS, Java, and C#. The choice of which backend to use largely depend on the use case. Java, for instance, is popular for desktops and software for businesses. NodeJS uses JavaScript and is popular for JavaScript web solutions; and improves the ease of use by using the same programming language for both the front and backend.

16.3.3 Choosing Between BaaS and Custom API

Choosing between backend solutions depends mainly on the complexity of the application and available resources. For a game with a less complex backend with simple logic, a BaaS is the most straightforward choice. However, a custom backend may be better if the application needs a complex backend with many integrations.

16.4 Summary

This chapter introduced relevant technologies for this project. We looked at different game platforms and operating systems for mobile and desktop. Then we discussed three possible

approaches, a native solution, a cross-platform solution, and a web solution for the game application. Finally, we discussed options for data management. The research from this chapter will be helpful when deciding on technologies used for development, detailed in Chapter 22.

Part III

Our Game Concept

This part describes our game concept, Escapade, and is based on our work in the specialisation project [9]. Original chapters have been modified. Chapters on Game Description, Requirements Specification, Software Architecture, Game Development Process, and Test and Validation of Requirements have been added.

We will introduce a list of new game concepts along with a description. These game concepts will be compared and assessed, along with a description of our selection process. The chosen concept will be specified further using game design theory from Part II. We will cover our functional and quality attribute requirements and selected technologies and the rationale behind our choices. Additionally, our game development process will be detailed. Finally, a test and validation of all requirements will wrap this part up.

Chapter 17

Proposed Game Concepts

This chapter will present six collaborative educational game concepts we considered for this project. For each concept, we will first describe the overarching idea of the game, followed by a summary of gameplay and cooperation elements.

17.1 Knowledge Dash

The first learning game concept we invented is *Knowledge Dash*. This concept is inspired by the popular endless runner game, *Subway Surfers*. In short, the objective of Subway Surfers is to avoid obstacles and collect coins, as shown in Figure 17.1. The player swipes horizontally to move the character between three lanes and vertically to jump or crouch. Knowledge Dash borrows some of these core gameplay mechanics.

In Knowledge Dash, the main objective is to answer questions that will pop up at the top of the screen. There are two game modes, a *normal*, and a *tandem* game mode. In the normal mode, answering the questions is reminiscent of the gates in Figure 17.2. The player takes control of a character and can move between four lanes, each with one gate. The speed of the character can vary depending on difficulty. Navigating the character into the correct gate will earn points for the player, while no points are gained for failing the question. Swiping up will cause the character to dash forwards to complete the question quickly. The shorter time used on each question will give more points if answered correctly.

In the alternative game mode, tandem mode, players in a team will collectively control the character. The character's direction will depend on the answer that the majority of the players in a group choose. However, a character's speed will be slower than the regular game mode to encourage discussion.

Figure 17.1: Subway Surfers

Figure 17.2: Angel or Devil Run

The gameplay in both game modes is team-based. At the start of the game, players type in a code and are assigned a team. A player in a team will collect points which will be summed up in the team. Groups in a classroom or even classes can then compete against each other. Furthermore, the points can be displayed on a screen in real-time for the whole classroom. The game will also feature the customisation of the character by collecting coins.

17.2 State of Crisis

State of Crisis places three to four players in charge of a near-future Norway where increased numbers and severity of natural catastrophes are causing high tensions in the country and the world. Players take on the roles of different minister positions in the Norwegian government and react to the internal and external consequences of situations they encounter. Players must work together to achieve common goals by ensuring their decisions are consistent with players' plans. As the players share the same pool of national resources, care would have to be taken to ensure players do not step on each other feet, further emphasising the need for communication between players.

A concrete example of a situation that could arise is a global oil shortage due to manufacturing plants in other parts of the world being impacted by extreme weather. The players would then have to decide how to react. They could increase oil exports to take advantage of the price increase, raising money for other projects. They could also decrease exports to create a stockpile in case a similar event hits Norway or keep it the same. Players would have to discuss the probable socioeconomic and environmental impact of their decisions and how their popularity as a government would be affected.

Once started, the game's time flows until the game is over, with no option to pause. This time restriction increases players' pressure and forces them to make decisions under time pressure, increasing the game's intensity and degree of immersion. The amount of time taken for one play-through would be suitable for a classroom lesson, around an hour. Removing the option to pause also ensures players can complete the game in time before the class is over.

State of Crisis is a browser-based game intended for the laptops and tablets commonly found in Norwegian classrooms. The game is fairly graphically simple, with all players seeing the same map view of Norway shown in Figure 17.3. This choice ensures that technical difficulty is kept relatively low so we can implement the game without the need for advanced game frameworks. Events would appear in the form of "pins" on the map, with players interacting with them to have event dialogue appear. This feature would help prevent players from being disturbed by new pop-ups while they are dealing with another situation, as would be the case if event dialogue just showed up on the screen.

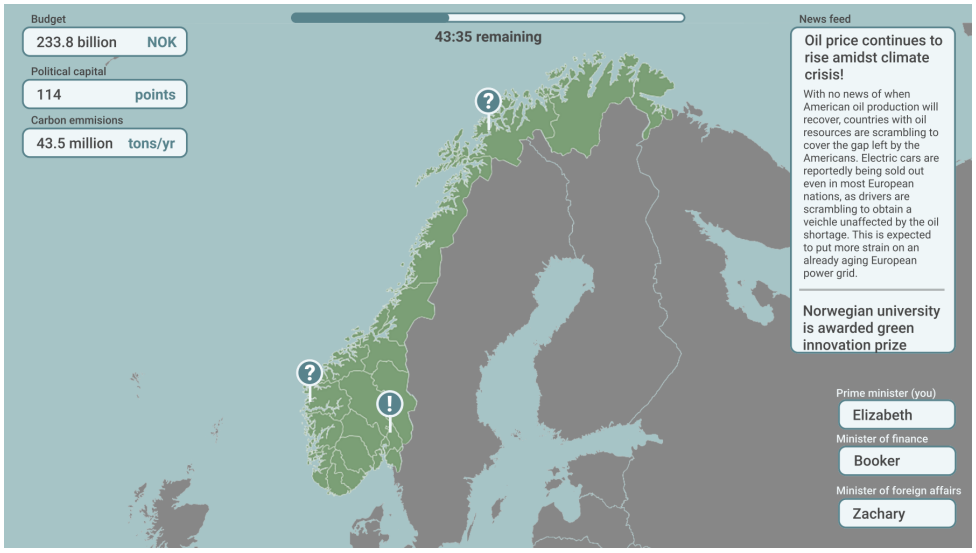


Figure 17.3: Concept game screen for State of Crisis. European and Norwegian map by FreeVectorMaps.com [72]

The learning goals of State of Crisis are twofold. The game would attempt to convey the practical effects of climate change (and how to mitigate or even prevent them) and how the government functions in Norway. The game is aimed at students in middle school and upper secondary school.

17.3 Detroit Tool Factory

Detroit Tool Factory takes place in 1937, a couple of years prior to World War II in the city of Detroit. The players are in charge of a civilian factory. During the following years, players will face a shift in the industry with World War II. Production items will gradually transition from car parts to war artefacts. This concept is inspired by the tycoon game genre, exemplified in Figure 17.4.

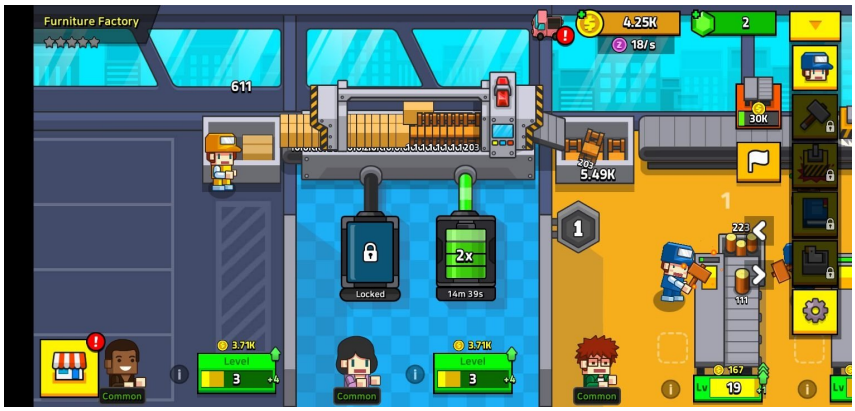


Figure 17.4: Screenshot from My Factory, a Tycoon Game

A factory in the game comprises multiple students, up to a whole classroom. Each player will have several available tasks to do. These tasks are split into *idle tasks* and *active tasks*. Idle tasks are run in the background and generate resources, like a part of a car motor. The player chooses an item to acquire. Acquisition time will then depend on the item, and the number of items that can be acquired will be limited. Active tasks generate game currency and require a player to do an action that requires resources generated from idle tasks. An example of an active task can be something as simple as wiring together wires, as seen in Among Us (see Figure 17.5) [73]. As time passes, classrooms will be able to upgrade their facility with in-game currency and resources, which unlock new parts of the game.

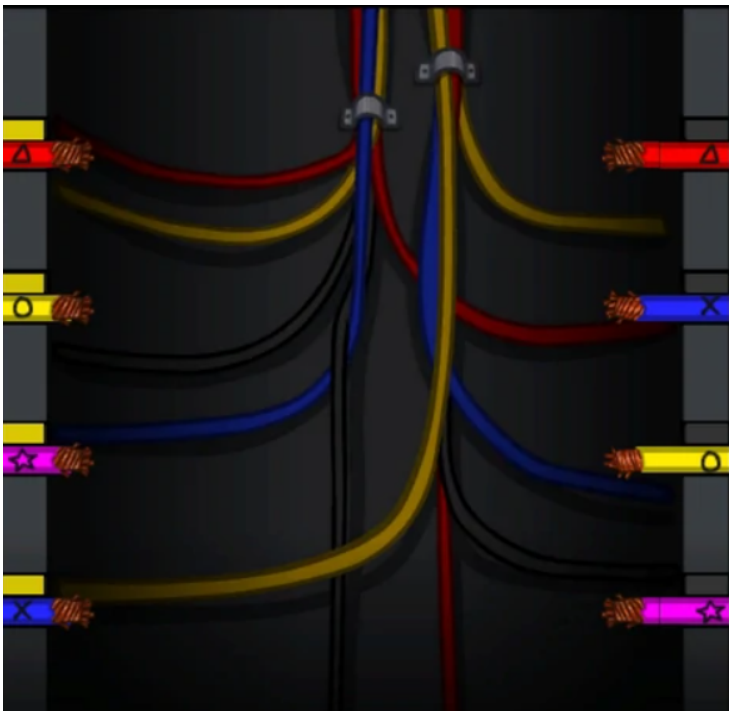


Figure 17.5: An example of a task in the game Among Us

Detroit Tool Factory will also feature intuitive ways for students in the same factory to cooperate. The game includes ways to get an overview of needed resources quickly, request resources and interact between players by trading. Competition can happen between groups within a classroom or between classrooms. A list of competing factories will be scored and ordered based on progress in their factory.

The game will be browser and mobile-based. The game intends to teach students how a typical factory was affected by a world war. An added learning objective can be to learn about components in certain items. Players learn what resources are needed to, for example, make simplified car parts. Furthermore, the game is intended to encourage cooperation within a factory to unlock more content.

17.4 Phish Splash

Phish Splash is a game where two teams compete to ”successfully phish” the opposing team while avoiding being phished themselves. Phishing, a social engineering attack, attempts to trick a target into trusting a malicious file or website. Email phishing often comes in the form of fake emails made to look from a trusted source, such as one’s employer, a social media platform, or an e-commerce website [74]. Each team consists of two players, one with the role of the defender

and the other one the attacker. The defender's game screen looks like an email client, with emails periodically arriving here throughout the game. Figure 17.6 shows a concept of what this screen could look like. Each email contains a file, and it is the defender's job to download files from legitimate emails while avoiding malicious ones sent by the enemy team. The attacker's game screen contains a tool that enables the sending of phishing emails to the opposite team. After a specific period, a winner is chosen based on the number of legitimate files clicked and illegitimate files avoided.

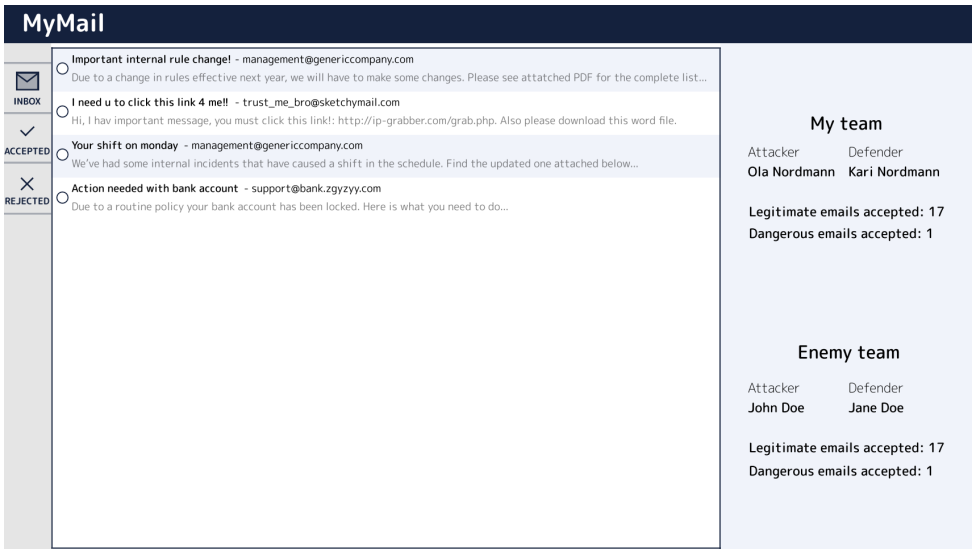


Figure 17.6: Concept for Phish Splash showing a defender's game screen

Phish Splash is mainly targeted at adults, with the game, for example, being played by employees at a company attempting to bolster their cybersecurity. As teammates gain more knowledge about the capabilities and strategies available, they have to communicate to be an effective team. The attacker, for example, could warn their defender about a feature available to attackers, indicating that the opposing team might use this feature as well. The game's goal is to educate players about what tools phishing attacks might use and improve players' ability to detect phishing emails among legitimate ones. The game is simple enough to be implemented in the browser, facilitating cross-platform play between mobile and PC without developing two versions. While the defender's game screen looks like an email client and messages between teams would contain similar information to real-life emails, the game uses a different format to prevent the possibility of sending phishing emails to targets outside the confines of the game.

17.5 Word Injection

Word Injection is based on the phrasal word game *Mad Libs* [75]. Mad Libs removes descriptive words like adjectives, nouns, and verbs from sentences. It is up to players to fill in the blank spaces with appropriate replacement words.

In Word Injection, the teacher chooses a story stripped of descriptive words. Afterwards, each pupil will join the game lobby with a code. Each player receives a set amount of letters associated with a score, like in Figure 17.7. A story, sentence for sentence, will unfold on the screen for the whole classroom. Pupils are split into pairs. The pair can then cooperate to lock in words, using letters for a replacement word that makes sense in the context of the current sentence. Scoring will be based on the *letter value* as well as *uniqueness* of the word. A common adjective like ”good” would not score many uniqueness points. On the other hand, an adjective like ”exceptional” would score considerably more points in letter value and uniqueness.

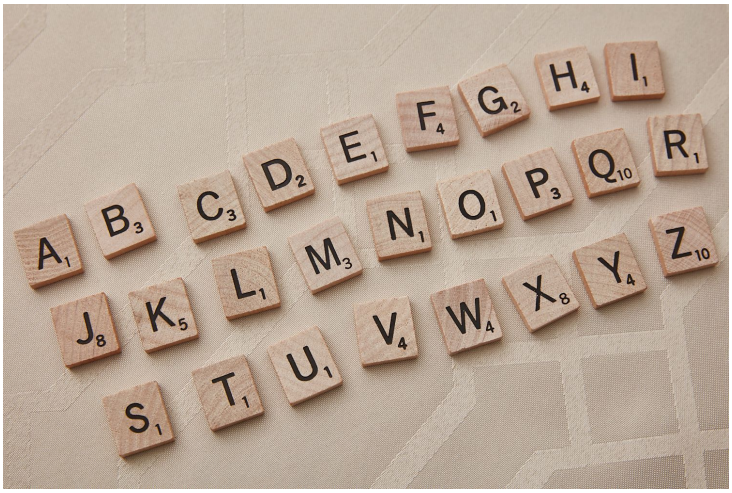


Figure 17.7: Points for each letter in a game of Scrabble

The learning focus of Word Injection is for students to cooperate and expand their vocabulary. The game is not limited to one language. It can be a great way of improving vocabulary in multiple languages. A problem that may appear in the game is students providing the game with swear words or nonsensical words. The game will require an option of prohibiting such words with a profanity filter and a way of determining accepted words.

17.6 Escapade

Escapade is a collaborative puzzle game based on the concept of high task interdependence between players, as discussed in Chapter 7. The game is played on a PC or tablet and is intended for an upper secondary school classroom setting. Players play in groups of three or four, with one player choosing the role of *explorer* and the remaining players being various *experts*. The game explains that the explorer has time-travelled to an unknown time and place. Together with a remote team of experts, they need to identify when and where they have been sent. The explorer is shown a historical image containing identifiers that make it possible to place where and when the photo was captured. A concept of how Escapade may look is shown in Figure 17.8.

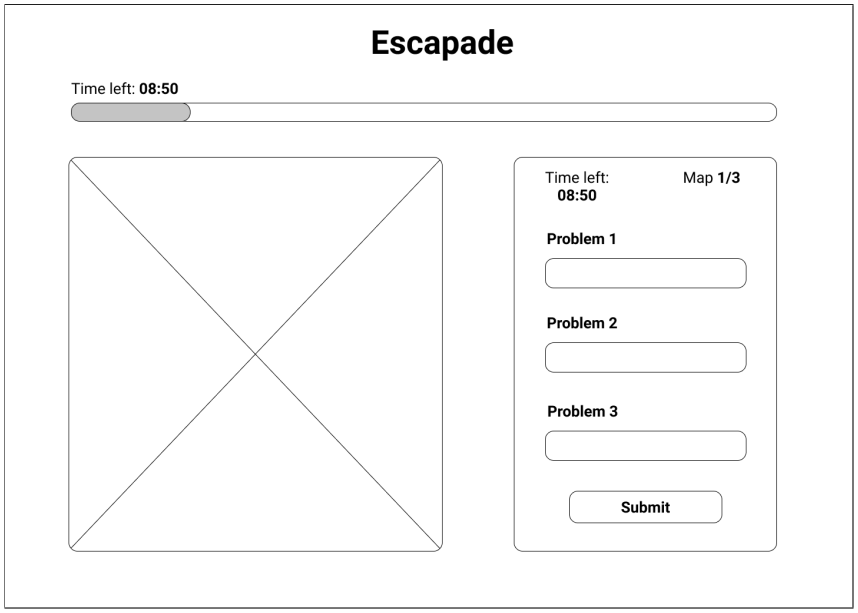


Figure 17.8: Concept for a game view in Escapade

To enable the game's concept of high task interdependence, players in the same group must sit so that they do not see each other's screens, as shown in Figure 17.9. In the game, this is explained by the time-space-communication link between the explorer and the experts only transmitting audio and not images. The experts each have access to data banks of information that is helpful when identifying where and when a picture was taken, with each expert having access to different information. One player might, for example, possess the role of military expert and therefore have access to images of uniforms, equipment and flags of various countries from significant historical points. This division of resources, where one player has access to the task while others can only see potential solutions, is reminiscent of Keep Talking and Nobody Explodes

(see Section 14.1), and to a lesser degree, It Takes Two (see Section 14.4). This structure forces players to communicate, and as each round will have a time limit, clearly defined roles and time stress should aid in overcoming any initial awkwardness within the player group.

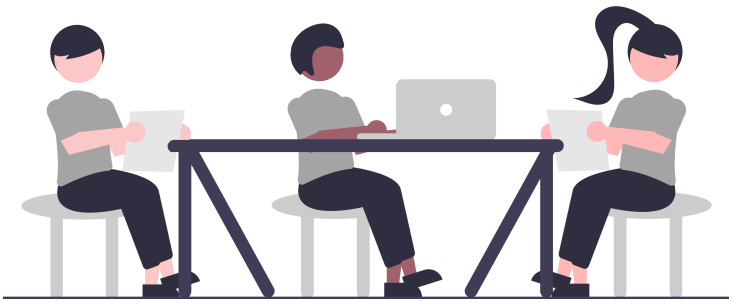


Figure 17.9: Players seated in a way where they do not see each other's screens

Once a group has decided on a location and date, the explorer enters this information into their game screen. The group is then awarded points based on how close they were to being correct. Teachers will make game lobbies to encourage inter-group competition in the classroom. Escapade is supposed to be an exciting way to learn about historically significant moments and to encourage discussion among students on a topic that might otherwise not engage them as much.

17.7 Summary

In this chapter, we introduced six new game concepts. We briefly described each game, focusing on gameplay, learning outcome, and collaboration elements. The next chapter will feature a detailed evaluation by comparing the concepts in the classification model (see Chapter 13). Afterwards, an impact-effort diagram will be introduced and applied based on the classification model and assessment of the games.

Chapter 18

Selection Process

This chapter describes the chosen game concept for this project and our reasoning behind the choice. Selecting a concept depends on a combination of things. Chapter 13 described a classification model. This model provided us with a structured way of analysing our ideas. This chapter describes our use of the model to gain an overview and analyse the strengths and weaknesses of each game concept. Additionally, we will use an impact-effort diagram to measure each concept's anticipated impact and effort. Both the model and the diagram are intended to help us choose the most promising idea.

18.1 Comparison of Characteristics in Game Concepts

This section will compare our game concepts using the classification model in Chapter 13. Table 18.1 shows a complete classification of all concepts from the last chapter. At first glance, all ideas share some of the same characteristics. This similarity is deliberate. The classification model served as our primary tool for constricting new concepts when creating new concepts. It helped us establish ideas that utilised the strengths and weaknesses we found in existing games (see Chapter 15). The subsequent sections will further describe the characteristics of our new game concepts.

Game Concepts							
		Knowledge Dash	**State of Crisis**	**Detroit Tool Factory**	**Phish Splash**	**Word Injection**	**Escapade**
Game Type	Browser		x		x	x	x
	Mobile game	x		x			
	Desktop game			x			
Game Genre	Puzzle	x			x	x	x
	Adventure			x			
	Simulation		x	x			
	Endless runner	x					
Target Group	Primary school students					x	
	Secondary school students	x	x	x		x	x
	University students	x	x	x			
	Employees				x		
Interaction	Out of game		x		x	x	x
	In-game	x		x	x		
	Collaborative	x	x	x	x	x	x
	Competitive	x		x	x	x	
Learning Effect	Primary effect	x	x		x	x	x
	Secondary effect			x			
	No significant effect						
Learning Field	Any	x					
	Geography						x
	History			x			x
	Social studies		x				
	IT security				x		
	Language					x	

Table 18.1: A comparison of characteristics of our game concepts

18.1.1 Game Type

Compared to the existing games we looked at in Chapter 15, our game concepts feature fewer game types. The reasoning behind this is closely correlated to the target group, specifically regarding access to devices. We wanted our game to be playable on all students' devices, which rules out console and VR devices. Another critical factor is that some game types automatically raise the required effort. For example, a VR game requires more effort due to the increased need for experience and development time.

18.1.2 Game Genre

Most of our concepts are in the puzzle genre. Similar to Chapter 15, this is of no surprise as most of the games we had inspiration from were puzzle games. Puzzle elements generally fit our goal of pursuing a productive learning effect with collaboration.

18.1.3 Target Audience

Our concepts primarily target upper and lower secondary school students and university students as the primary audiences. This targeting does not say that our concepts cannot be more ubiquitous. Our primary motivation for creating a distinction is for the case of feasibility. One important note is that digital devices are limited the younger the students are.

18.1.4 Interaction Between Players

One requirement of our concepts was the collaborative aspect. Some of our concepts also include a way of competing. Additionally, a significant difference between the concepts is whether players interact out of game, in-game, or both. As discussed in Section 15.4, interactions between players outside of the game can be physical and digital. This distinction is noteworthy as digital classrooms have been increasingly necessary in light of the COVID-19 pandemic.

18.1.5 Learning Effect

A critical focus for our concepts was the learning effect, which we correlate to impact level. Our goal is to make a game that will draw in players despite its effect of being educational. Creating a good learning game requires a simultaneously educational and entertaining concept, necessitating an exciting idea that is not sacrificing its learning effect. We should note that even though the learning effect has been ticked as only a secondary effect in Detroit Tool Factory, we believe that the game would still be sufficiently educational to be considered a learning game. Categorising its learning effect as secondary means that learning being a game's goal is not immediately apparent.

18.1.6 Learning Field

Lastly, the characteristic of the learning field is diverse in our concepts. As discussed in Section 15.6, it is vital to either make a game wholly universal or restrict it to one or more specific areas. During brainstorming, the challenge of creating ideas with versatile learning fields ultimately ended up with a quiz format of some sort. While not inherently wrong, many creative options become available when straying away from a quiz format. Because of that, our concepts shift focus towards restricted learning fields except in the case of Knowledge Dash.

18.2 Impact-Effort Diagram

An impact-effort diagram is used as a prioritisation tool for activities, or in our case, concepts [76]. The goal is to utilise available resources to choose an idea we believe will be the most impactful. The process starts with selecting an impact level and then the effort level of each concept. Afterwards, we place them accordingly in the diagram. Figure 18.1 shows the diagram split into four quadrants. Concepts landing on the top half are considered ideal, while we should avoid those at the bottom.

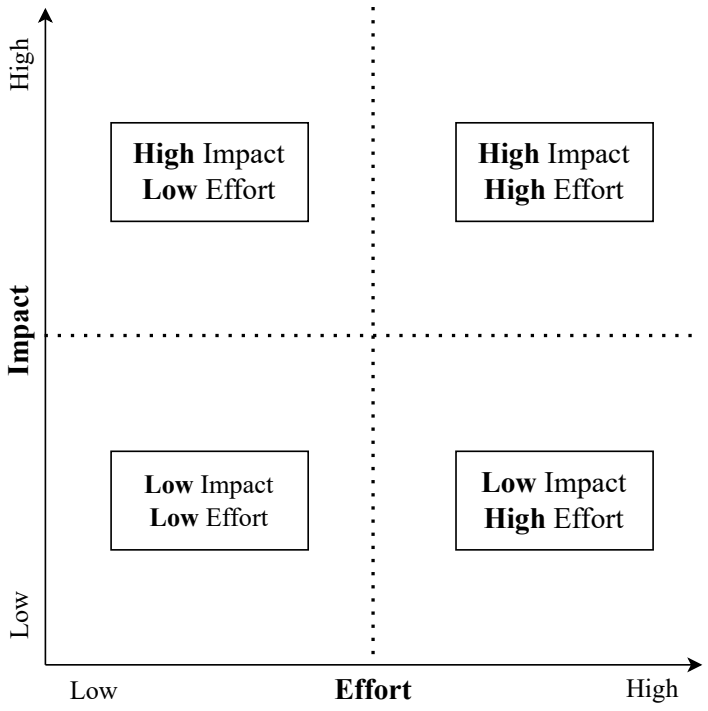


Figure 18.1: Impact-Effort diagram example

18.2.1 Impact Level

We decided that the impact level was to depend mainly on *motivation*. As stated in Chapter 1, creating a game of positive societal impact is important. Furthermore, the concept should be exciting and engaging in a way that draws players back to play despite the game's educational focus. Additionally, the impact level relies on our expressed enthusiasm for the given concept.

18.2.2 Effort Level

The effort level given depends mostly on two factors, *feasibility* and *technological complexity*. Feasibility is a decisive evaluation criterion for this project. It includes factors like the practical-

ity of the concept, i.e. in what grade it is achievable to fulfil the concept and deploy the solution. A solution including VR would earn a high effort score as it would be hard to procure enough VR headsets. Additionally, the concept should be possible to test for a given target group.

Chapter 16 introduced an overview of relevant technology. The technology which the different concepts require brings limitations in terms of experience and complexity. For example, an idea reliant on custom 3D graphics would score a high effort level. It is outside our team's experience level and has a high degree of complexity.

18.3 Evaluation of Game Concepts

This section will evaluate each game concept based on the characteristics of the said concept. Then each game will be assessed in terms of effort and impact, then scored and placed in a corresponding impact-effort diagram as illustrated in Figure 18.2. Each axis in the chart for impact and effort levels will be ranged from 1 to 10, and we will place each concept accordingly.

18.3.1 Evaluation of Knowledge Dash

Knowledge Dash is a mobile-only game. The game genre is both a puzzle and an endless runner. The learning outcome of this game is versatile, as questions that pop up can be of any learning field. Knowledge Dash is, at its core, a dynamic quiz game.

Knowledge Dash's impact depends on whether the format fits in a classroom. If the concept is successful, it will provide an excellent learning effect in a fun format. The biggest challenge for the game is striking a suitable balance for the speed of the running character. If the character moves too fast and students have too little time on a question, it may become too fast-paced. This difference can cause some players to lag behind and lose motivation.

On the other hand, if the character moves too slowly, the game may feel sluggish and slow. The game is also limited to one platform, which may pose a problem for accessibility. These considerations leave the game with an impact level score of **5**.

The concept is based on 3D graphics and will require technology frameworks that we do not have experience with. In terms of feasibility, it will be possible to test the solution as long as students possess mobile phones. However, deploying the game to multiple mobile platforms will require extra effort. The effort level of the concept is high with a given score of **7**.

18.3.2 Evaluation of State of Crisis

State of Crisis is a browser-based game designed with a desktop interface. It is a simulation game restricted to teaching students social studies, for example, politics.

The game is session-based with a time limit; it provides an intense experience without pauses. This time restriction can increase immersion for the player, resulting in a good flow state, as discussed in Chapter 9. One major drawback of the concept is the lack of replayability. The game is primarily scripted with self-designed outcomes depending on actions taken, dropping the player's inclination to play the game again and diminishing the societal impact we aim for. The impact level for State of Crisis is **4**.

Even though the game has simple graphics, the concept depends on a scripted design system. This choice means we would have to anticipate and script interactions, which would be a complex and time-consuming process to get right [77]. A solution would be to embrace an emergence design game environment, but this would fall out of our area of expertise. The effort level we decided upon is **9**.

18.3.3 Evaluation of Detroit Tool Factory

As it is possible to generate idle resources, we decided that Detroit Tool Factory would be a desktop and mobile game. The players can collect resources on multiple devices for a cohesive user experience. However, there is a significant drawback. The game can become too dependent on incentivising players to check the app often to collect resources. The game can lead students to become distracted by constantly picking up their devices during classes, which lowers the impact score of the game.

Additionally, Detroit Tool Factory is a simulation and adventure game where the primary learning field is history. The game is more gameplay-focused, causing learning to become a secondary effect. The educational elements in the game consist of learning history through experiencing events in the game and through items the factory will produce. The learning outcome is not sufficient for achieving enough positive societal impact. As a consequence, the impact level of Detroit Tool Factory is low, with a final score of **3**.

The game would also require the design and graphics of a game environment with items, characters, and sceneries in 2D or 3D. These requirements add a substantial need for resources and complexity. The technical complexity is also extensive as the idea involves planning, developing,

and maintaining two codebases. The resulting effort level score is thus high at **10**.

18.3.4 Evaluation of Phish Splash

Phish Splash is intended to be a puzzle browser game that strengthens IT security foundations for players. This concept differs from other concepts as the target group is business employees, which means the game does not meet the requirement of a collaborative classroom lecture game. However, we decided not to dismiss this concept as the game could still provide valuable out-of-curriculum learning outcomes for students in classrooms. Phishing attacks are still common and relevant for all age groups [74, 78]. The learning potential for this concept can offer a positive societal impact. We landed on scoring the concept with impact level **6**.

Phish Splash is based on users interacting with a made-up email client. The game requires a series of scripted interactions between players, which would require a lot of planning to create enough content. The lack of content highlights another issue, which is replayability. The game offers little replayability, as there are limited attacking and defending patterns. New ways of playing the game are necessary to keep the game interesting in the long term. In turn, it will add increased technical complexity to the game. The effort level score is thus **7**.

18.3.5 Evaluation of Word Injection

Word Injection is a puzzle browser-based game to support mobile and desktop devices. We can make browser games to support multiple screen sizes with responsive design, as discussed in Chapter 16. However, it requires consideration in the game's user interface design and interactions.

As the concept is based on teaching language, it is targeted at students with language courses. Potential players will most commonly be students from primary to secondary school. The game is limited in learning outcome as it focuses solely on one part of the language, namely vocabulary. This concept can at most be seen as a supplement to language courses, resulting in the envisioned societal impact being low at **4**. Word Injection is graphically simple, with straightforward game mechanics. The effort level score is thus **4**.

18.3.6 Evaluation of Escapade

Escapade is intended to be a browser-based game with support for responsive design in the same way as Word Injection. The game revolves around high task interdependence between

players caused by heterogeneous resources, as discussed in Chapter 7. Not many games utilise heterogeneous resources, which makes Escapade alluring. The learning outcome of the game also affects two fields, history and geography, which further increases the potential for a positive societal impact. Escapade is targeted at secondary school students. If successful, it can provide more value to people wanting to play the game for fun outside the target group. Additionally, this was the concept we expressed the most motivation to explore further, giving it an impact level score of **8**.

While Escapade is not graphically intensive, the game requires text, images, and replayability. Planning, finding, and developing a wiki-like data bank will require considerable time. A significant challenge for this concept is introducing a form of replayability to encourage students to play. The resulting effort level of this concept is **9**.

18.4 Choosing a Concept

The ensuing impact-effort diagram can be seen in Figure 18.2. As mentioned in Section 18.2, the ideal concepts should land on the upper half of the matrix. We agreed on this ideal and cut three ideas: Word Injection, State of Crisis, and Detroit Tool Factory. Furthermore, Phish Splash provides a higher impact level and the same effort level as Knowledge Dash. We decided, therefore, to remove Knowledge Dash.

Between the remaining two concepts, Phish Splash is of lower impact than Escapade. However, Escapade is of a higher anticipated effort level. Choosing between these two depends on what we want to prioritise, higher impact or lower effort. We based our motivation on creating a fun game with a positive societal impact, thus ultimately deciding upon Escapade as we believed it was the one with the most potential. Even though the effort level is high, we still deemed it feasible for the duration of our Master's thesis.

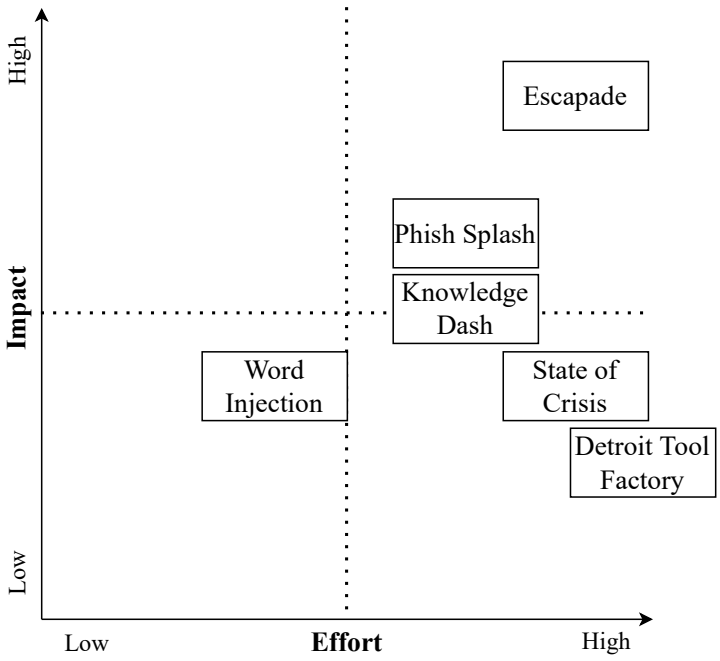


Figure 18.2: Impact-Effort diagram of our concepts

18.5 Summary

This chapter goes through our rationale behind the selection process for game concepts. Then we covered how we use the impact-effort diagram in conjunction with the model of classification described in Chapter 13. The impact level score mostly depends on our motivational factors, including positive societal impact. The effort level score depended on feasibility and technological complexity. Finally, we evaluated all the game concepts and placed them accordingly in the impact-effort diagram. Of all the concepts, the evaluation found Escapade the most likely to fulfil the research goal with an appropriate impact and effort level. The next chapter will provide an overview of Escapade, screenshots included.

Chapter 19

Game Description

This chapter will further expand on Escapade's description provided in Section 17.6, which describes it as a puzzle game where groups of players must work together to identify the situation, time, and place of a historical image. The game aims to increase interdependence between players by only allowing one player to see the historical photo and having the remaining players act as experts, each with access to different databases of helpful information.

The following sections will provide a descriptive overview of the game, including screenshots from the game prototype. These views are based on low-fidelity wireframes from our specialisation project [9]. Figure 19.1 shows a view of the game when it is first accessed.

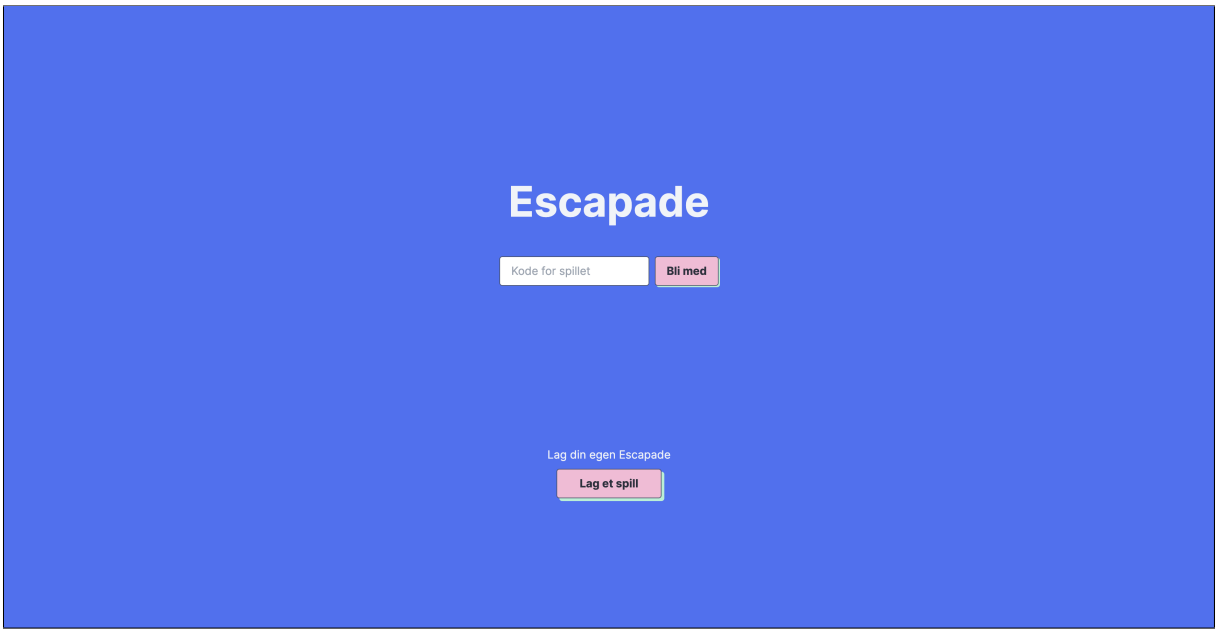


Figure 19.1: The main view of Escapade

19.1 User Flows

The game is intended to be used by two groups of people, a host (teacher) and players (students). Figure 19.2 and Figure 19.3 presents an overview of simplified flows for both instances of users.

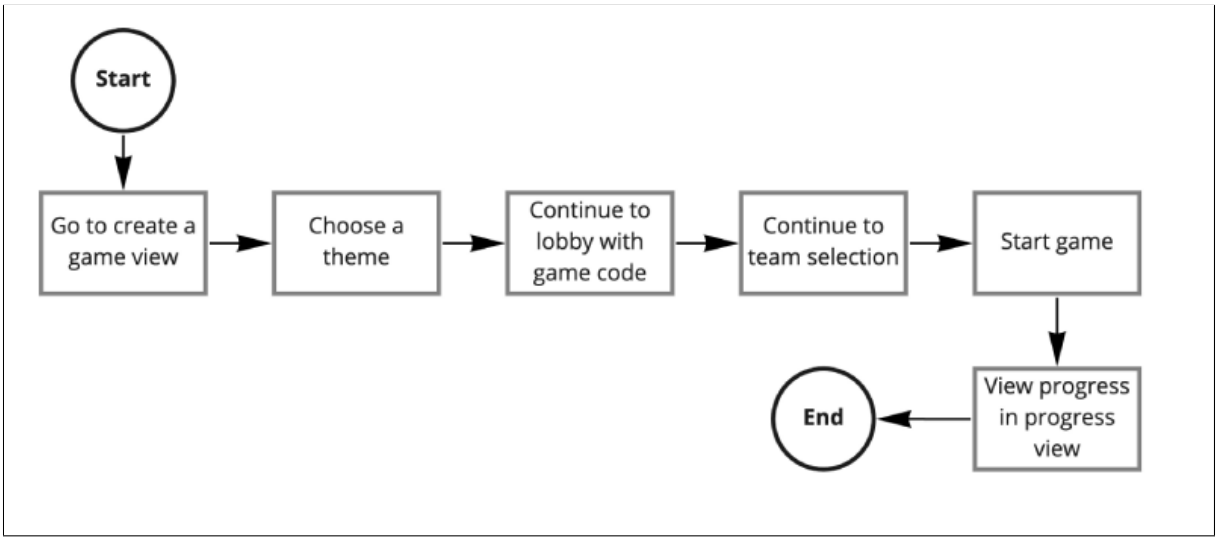


Figure 19.2: Host user flow

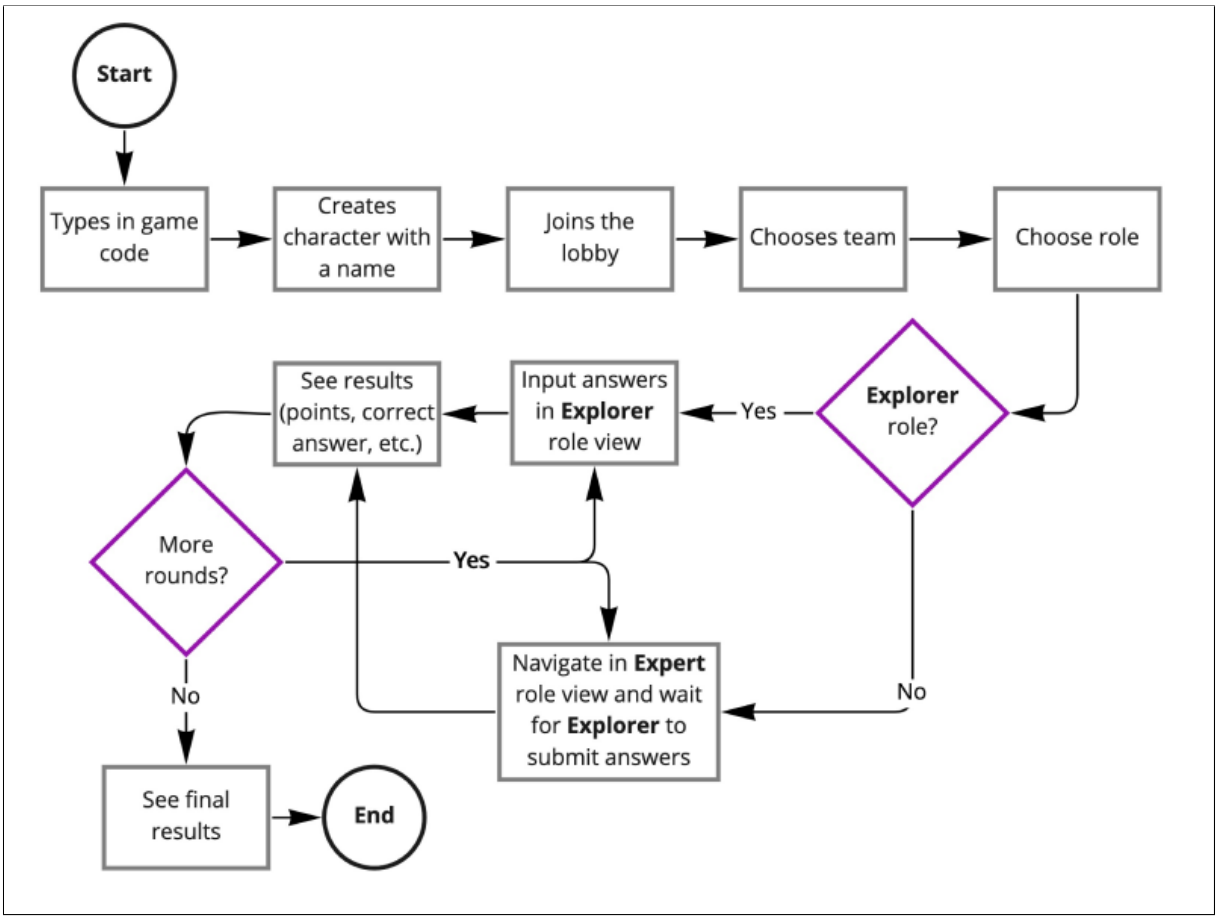


Figure 19.3: Player user flow

19.2 Creating a Game View

When first accessing Escapade as a *host*, a game can be created by pressing the corresponding button in Figure 19.1, leading to Figure 19.4. The *host* can in this view select a theme for their ”escapade”. Each theme contains a set of maps that players will go through, shown with the corresponding historical images.

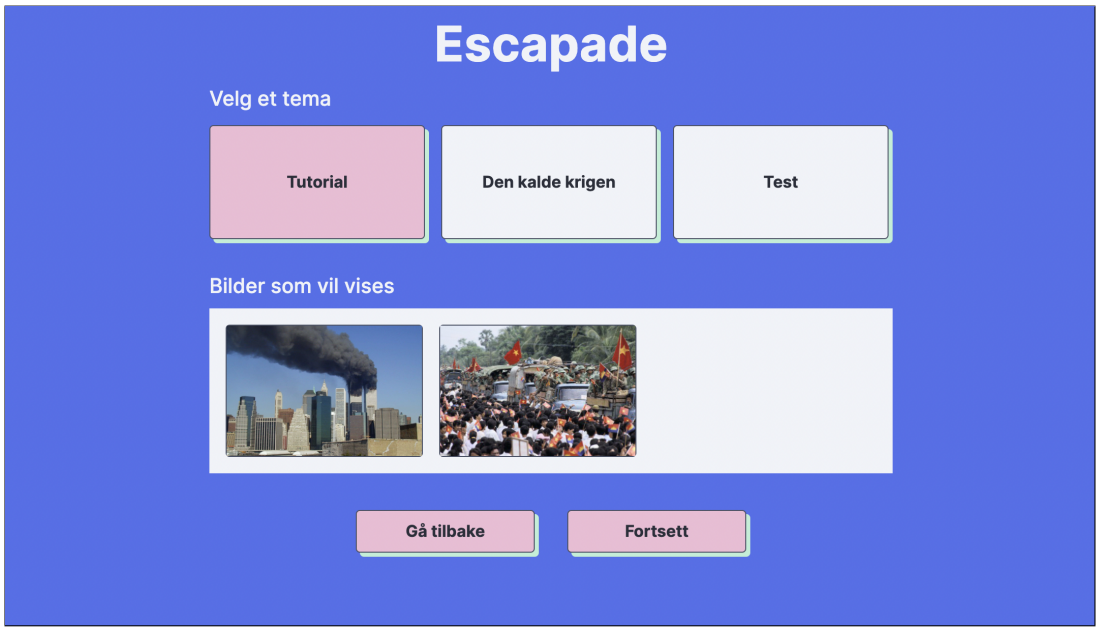


Figure 19.4: Host view when creating a room

19.3 Character Creation View

Players will start at the same view as *hosts* in Figure 19.1. After typing in a code and choosing to join the lobby, the player can customise their avatar and name as displayed in Figure 19.5. Arrows on the sides of the avatar are intended to change one part of the character at a time. There is also an option to randomise the avatar.

Figure 19.5: Player view during character customisation

19.4 Lobby View

By continuing as a *host*, the game will generate a game code that *players* use to join the room. This view is similar to how Kahoot! [60] handles a lobby.

As depicted in Figure 19.6, the *host* can see all the *players* that have joined in real-time. This view is intended to be shared with the classroom. The *host* can confirm that all *players* have joined before starting the game with this overview. The lobby view is similar for *players* with the ability to continue the game process being replaced with a waiting animation, shown in Figure 19.7.

Figure 19.6: Host view when in the lobby

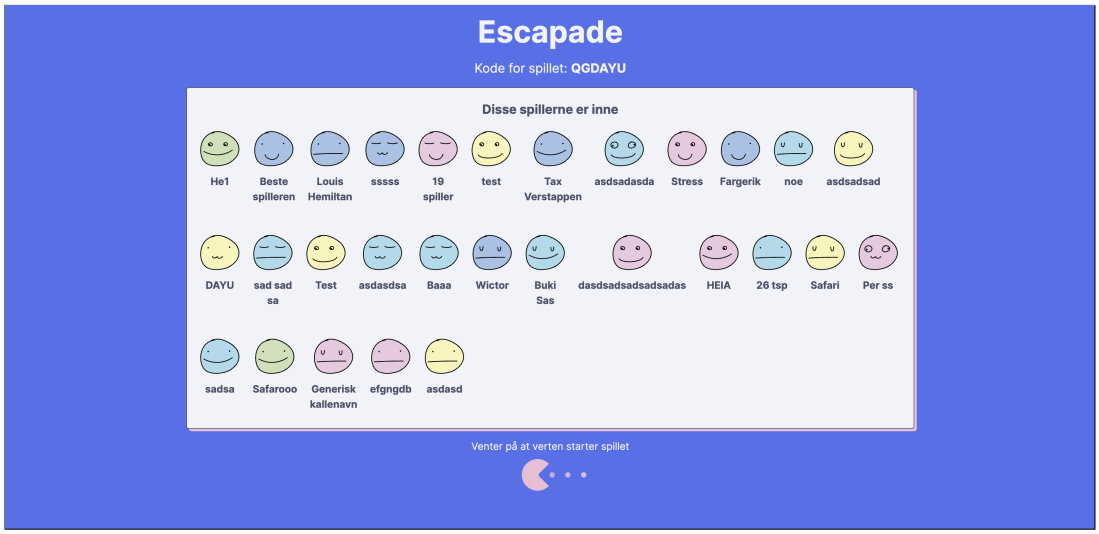


Figure 19.7: Player view when in lobby

19.5 Team Selection View

When everyone has joined, the next step is choosing a team. The *host* will have an overview of all teams as illustrated in Figure 19.8. In this example, there are nine teams, which can be seen by scrolling down in the container. This view is updated in real-time and displays players that are not assigned yet. The number of teams is automatically determined based on the number of players.

The *players* are encouraged to sit together with their team in the classroom, and choose their team in this view accordingly. The *player* view is shown in Figure 19.9.

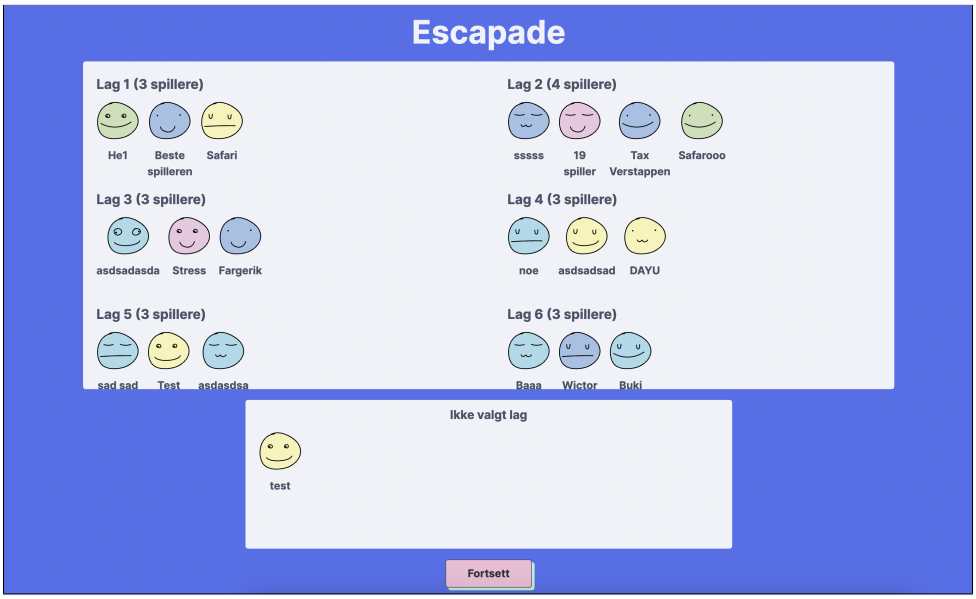


Figure 19.8: Host view during team selection

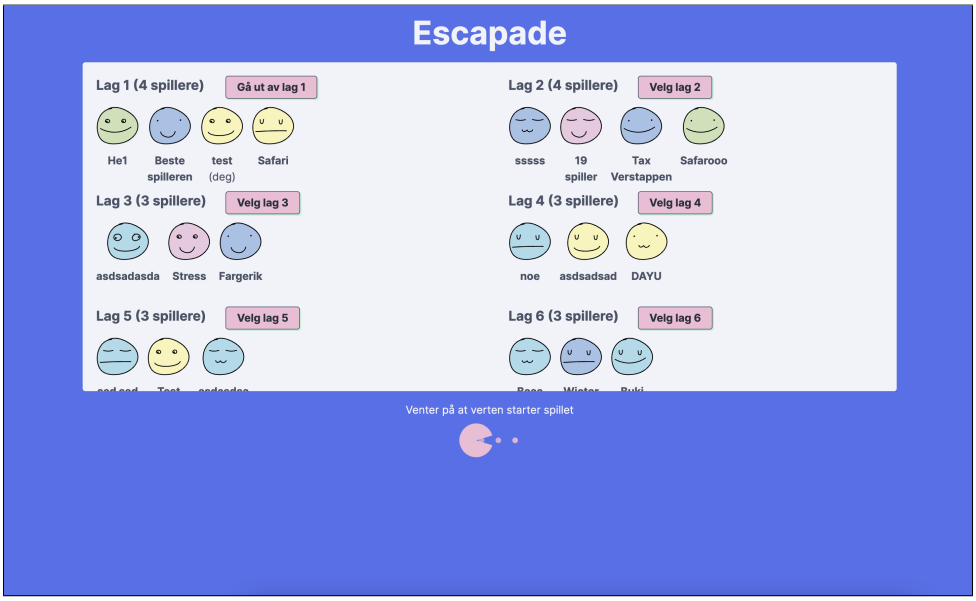


Figure 19.9: Player view during team selection

19.6 Role Selection View

After selecting a team, *players* are now ready to choose a role, as shown in Figure 19.10. Each role includes the role's title and a short description. Each team may start the game whenever they are ready.

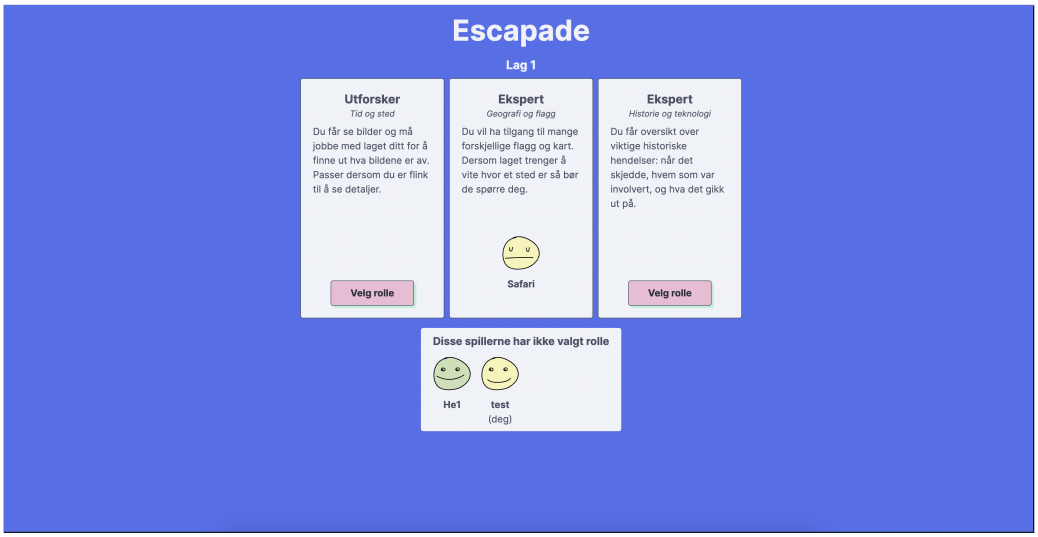


Figure 19.10: Player view during role selection

19.7 Game Progress View

After the teams are assigned, the *host* will see a progress view as illustrated in Figure 19.11. This view contains all team progress information, such as round information and points. For the *host*, this view will persist for the remainder of the game.

Figure 19.11: Host view during an active game

19.8 In-Game Views

When players are in-game, all players are provided information like time left and which round they are on. Furthermore, the view will vary depending on the three different roles.

19.8.1 The Explorer Role

For *explorers*, this view is shown in Figure 19.12. Explorers can set a pin on an interactive map for questions requiring a location, as shown in Figure 19.13. The explorer role is responsible for submitting the answers to the team.

Figure 19.12: Player view in-game for the explorer role

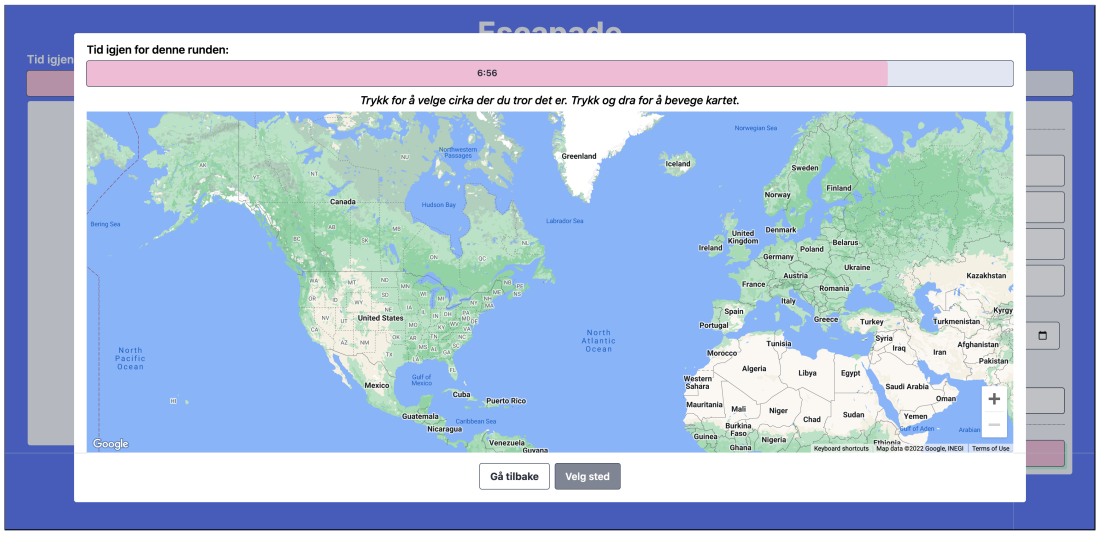


Figure 19.13: Map used by the explorer to select the location of where the picture was taken

19.8.2 The Expert Roles

The *expert* roles have a different set of responsibilities and thus have different views. For the *geography and flag expert*, a wiki-bank of maps and flags is displayed, depicted in Figure 19.14. For the *history and technology expert*, the same layout is used, but with an information bank of historical situations and technology sorted by years. This expert view can be seen in Figure 19.15

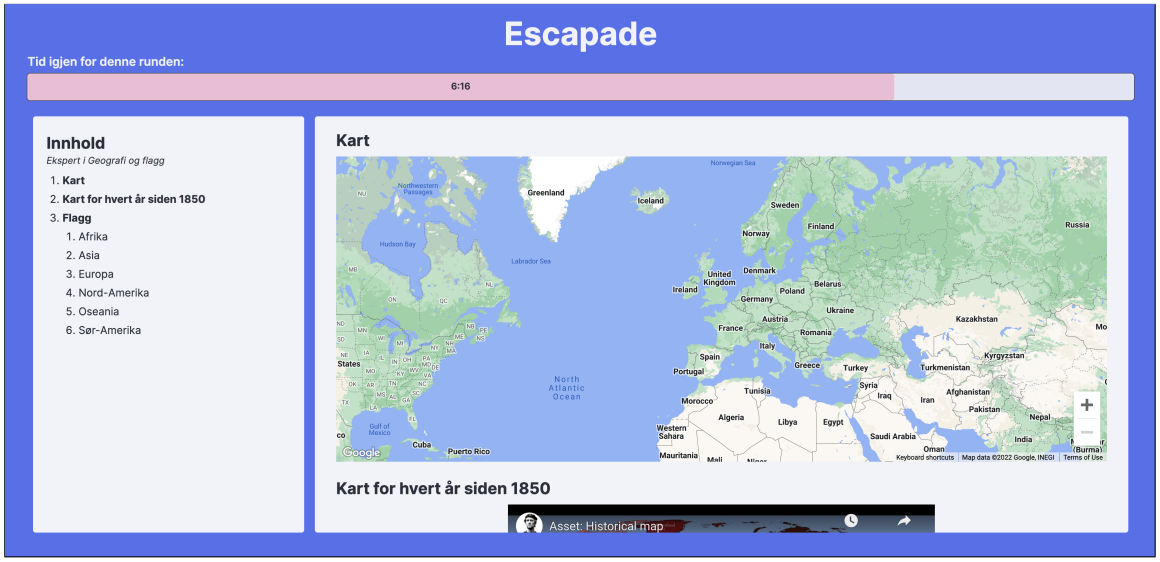


Figure 19.14: Player view in-game for the expert role in geography and flag

Figure 19.15: Player view in-game for the expert role in history and technology

19.9 Result Views

All *players* will receive feedback after every round, as well as at the end of each game. Figure 19.16 shows the view every member of a team will see after each round. This view shows the group's answer, the correct answer, and points for each question. Figure 19.17 displays the view after all rounds are completed with a confetti animation. Additionally, the result views feature a count up animation for points before fading in the rest of the content.

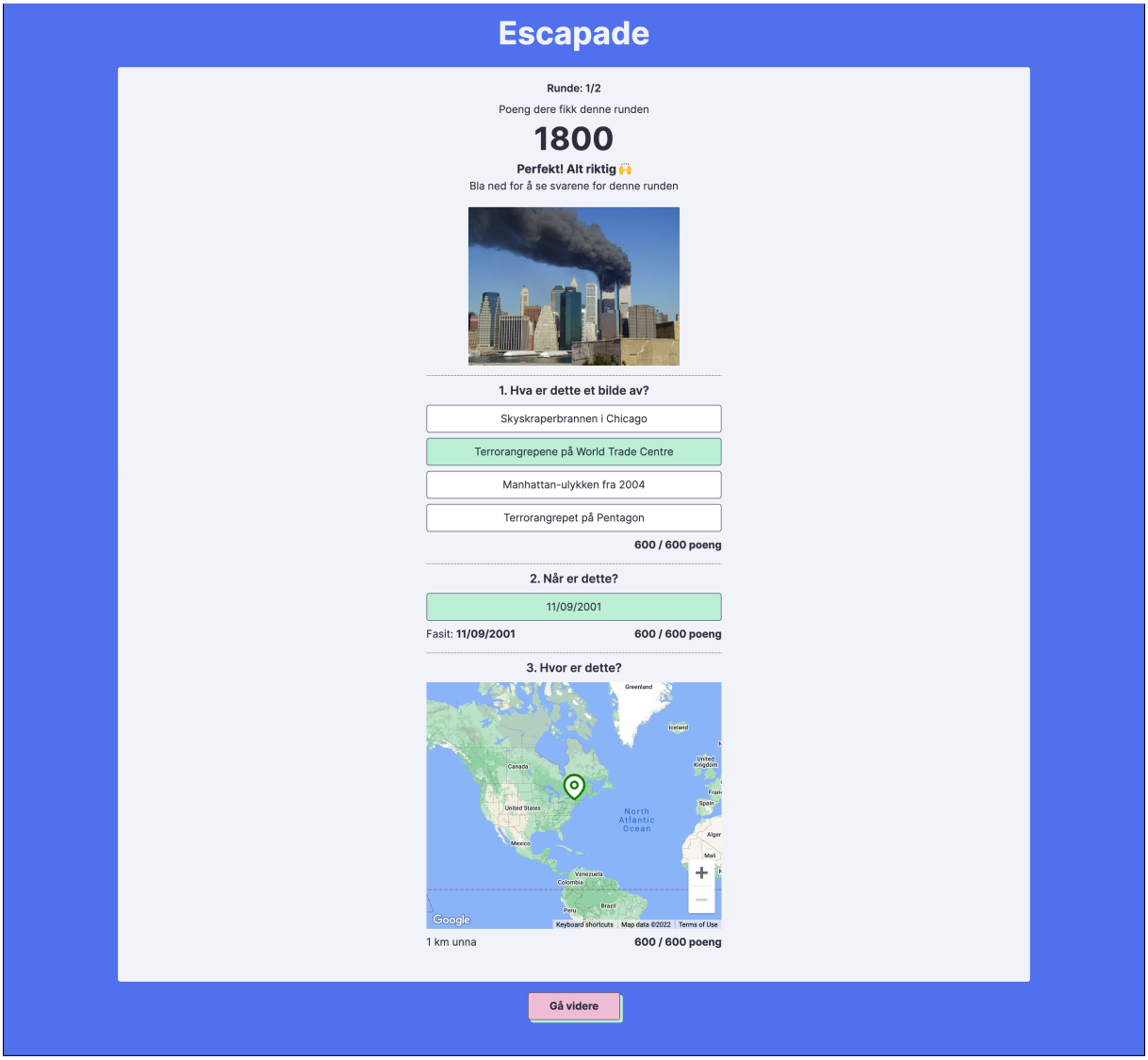


Figure 19.16: Player view after each round

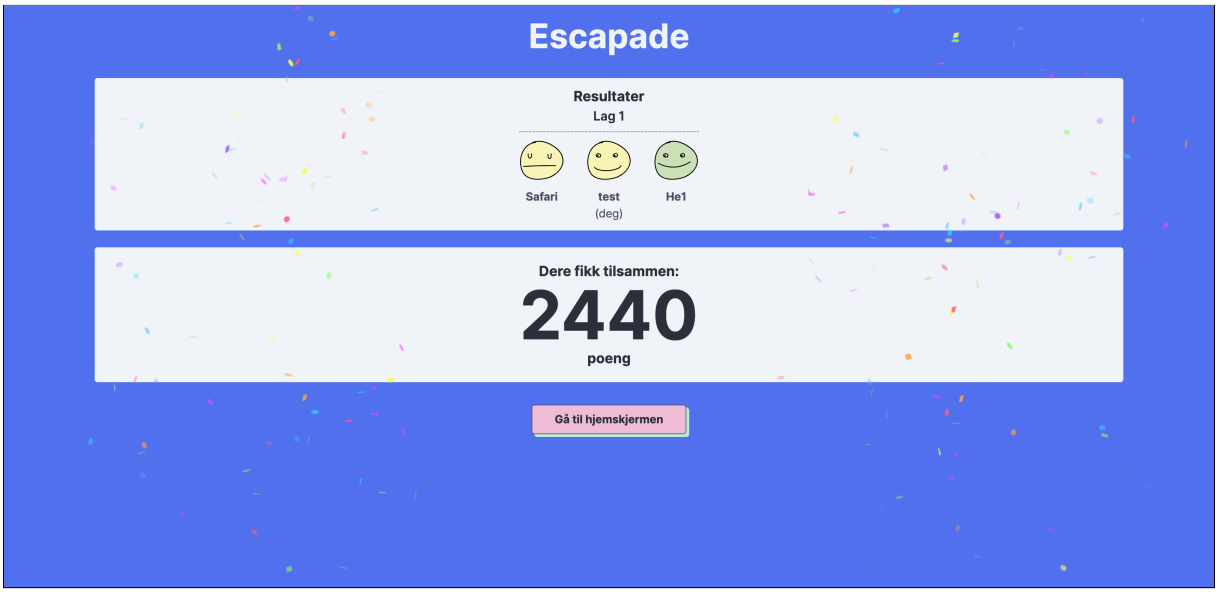


Figure 19.17: Player view after completing all rounds

19.10 Summary

This chapter provides an overview of the game by describing user flows and user interface using screenshots from the game. All choices forming Escapade's user interface are rationalised in the next chapter, where we will elaborate on how we tie game design principles from Part II to the prototype.

Chapter 20

Game Design

This chapter will systematically detail how we designed Escapade using the theory described in Part II. It is worth noting that not all principles are included as we have focused on the main components.

20.1 The Jigsaw Method

Facets of the jigsaw method (see Chapter 7) feature prominently in Escapade to increase task interdependence. One of the game's central mechanics is that players are presented with different information while unable to look at each other's screens. This mechanic means that the group is dependent on information distributed among all players, placing a responsibility on each player to communicate their unique data. This responsibility can act as a motivating factor and lead to a more active learning process. In active learning, learners work to connect new material to known concepts. As discussed in Chapter 6, active learning is recommended in constructivist learning theory, fostering a more profound understanding than less active methods like simple repetition [19].

Another advantage to creating a game around increased interdependence is how it encourages inclusion in a group. A group where every member is needed is less likely to form cliques that exclude certain members from solving a task since any clique would automatically lack the information of the excluded people. The jigsaw method was initially created to lessen tensions and encourage classroom collaboration when students were highly agitated and non-inclusive towards each other. As the technique has been employed successfully for this task, it is sensible to think it can aid inclusion in less tense classrooms.

20.2 What Makes Things Fun to Learn?

This section describes how Malone's guidelines for a fun game with three factors: challenge, fantasy, and curiosity, apply to Escapade.

20.2.1 Challenge

A balanced challenge is essential in giving the player a good experience in the game. When designing the challenge aspect, it is crucial to consider students' different experiences and skill levels.

The main *goal* of Escapade is to deduce place, time, and other information in an image by collaborating with a team. The goal is also related to a fantasy, where the explorer is to ultimately time travel back to their original time.

Uncertain outcome is also an aspect that Escapade takes advantage of. The difficulty level in the game will vary in mainly two different ways. The first one is a consequence of having specific roles in a team, an explorer, and experts. The roles of experts will be of varying difficulties depending on the kind of expert the student plays. Furthermore, the difficulty will differ between an expert that finds and provides answers and an explorer that describes and forms questions. The other way to tweak difficulty is by adjusting time limits or choosing different themes.

Additionally, Escapade introduces a way of having multiple goals implicitly. Because of the nature of the game being time-boxed, groups can have a meta goal of trying to beat their own time. The time left is displayed with a bar (see Figure 20.1) on top of the page each round.

Figure 20.1: Bar showing how much time is left of the round

20.2.2 Fantasy

The fantasy of Escapade is first described in Section 17.6 about an explorer who time travels. Accompanying the explorer is a team of experts who only have one means of communication: voice.

Escapade uses extrinsic fantasy by relying on a team's communication skills to affect the fantasy of time travelling. Malone suggests that emotionally driven fantasies like war and competition are popular. The imagination in Escapade of time travelling allows the game to visit such fantasy categories. Choosing a theme like World Wars lets the players immerse themselves in this emotionally driven setting. Additionally, every player customises an avatar, which creates an extrinsic fantasy where players accumulate points for the team through their avatar. Examples

of avatars are shown in Figure 20.2.

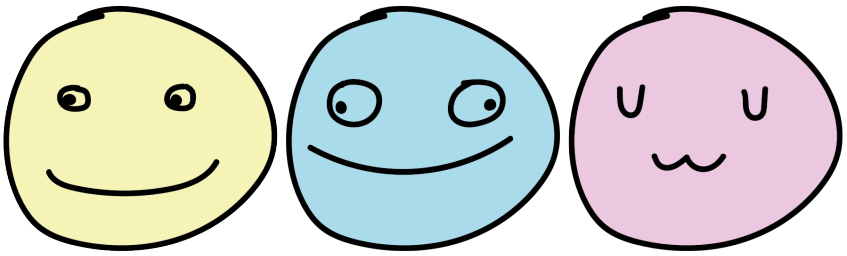


Figure 20.2: Examples of customisable avatars

20.2.3 Curiosity

Curiosity is vital for motivation and retaining a player's attention. Escapade is intended to stimulate both a player's sensory and cognitive curiosity. Sensory curiosity will play a crucial part in the game's visual effects design. Pleasing graphics will be necessary, especially regarding feedback and Escapade's reward system, elaborated further in Section 20.4.

Cognitive curiosity plays a critical part in Escapade as a direct influence of the jigsaw method and the constructivist view of learning. The jigsaw method and the constructivist view Malone's theory on cognitive curiosity and the main point of Escapade is to complete a knowledge structure by assessing an image. However, stimulating a player's cognition in the game depends on the choice of pictures and wiki banks. Including photographs and information that players already have complete knowledge structures about will not appeal to their curiosity. It will thus be essential to provide options for varied or less famous images.

20.3 GameFlow

The GameFlow framework, based on Csikszentmihalyi's theory of Flow, attempts to create a general idea of enjoyment in video games. This project aims to create an educational and entertaining game despite its educational value, so trying to incorporate theories of game enjoyment into our design makes sense. GameFlow is covered further in-depth in Chapter 9. While not all of GameFlow's eight elements are equally relevant to our project, most of them have been considered in the game design:

Concentration

A game should require the player's concentration without overwhelming their mental limits. Escapade aims to achieve this by introducing intergroup competition and a per-round time limit. Scores at the end of each round, inspired by Kahoot!'s system, should cause players to be more interested in performing well, as was shown in an experiment that looked at the effect of the points system (among other things) on player's experience with Kahoot! [61]. All players will have to concentrate on communicating as many details with each other as possible, while experts will likely also need to go through large amounts of information in a short time.

Challenge and Player Skill

A tutorial game theme should help introduce players to the game mechanics. Players will have the same starting point in a game regardless of their skill level since they compete with the same terms. Escapade does not require success for players to progress in the game, as each round is time-boxed. Each group will fine-tune their estimated place and date for an image to the best of their ability. While one group might be able to place a photo on the exact year it was taken, another group might find sufficient challenge in identifying the correct decade.

Clear Goals and Feedback

The elements of clear goals and feedback primarily apply to the user interface in our case. Players playing Escapade always have the same goals, and the user interface needs to communicate these (i.e. context, when and where was this picture taken). Players also need to receive adequate feedback when submitting their guesses. Figure 20.3, Figure 20.4, and Figure 20.5 show different feedback for three different scores. Performance feedback is also included to engage a player's self-esteem, as suggested by Malone [27]. Players will be shown how many points they received after each round, the maximum available points, and how far away they were from the correct answer. These will be presented separately for the situation guess, time guess, and the place guesses so players can understand where they lost and collected points.

Figure 20.3: Feedback for a low score

Figure 20.4: Feedback for a medium score

Figure 20.5: Feedback for a perfect score

Immersion

While not a significant area of focus for our game, the immersion element of GameFlow concerns whether players can feel ”deep but effortless involvement in the game” [29]. The inclusion of a straightforward narrative element can be advantageous to immersion. In Escapade, it explains that players have travelled in time and need to identify where they are.

Social Interaction

Sweetser and Wyeth describe social interaction as usually counter-productive to a game’s potential for flow experiences. Despite this, they recognise the enormous potential for enjoyment social interaction can bring to a game. Escapade heavily relies on social interaction both for enjoyment and learning outcomes. The game implements social interaction through intragroup collaboration and intergroup competition, both core to the game’s mechanics.

20.4 Game Reward Systems

As described in Chapter 10, game reward systems play a prominent role in fostering motivation among players. Since motivation is essential in learning, player motivation is vital. That being said, the design and significantly the scope of Escapade limit our choice of rewards somewhat.

This design and scope are further expanded upon later in this section.

The main reward in Escapade, which is also its main driver for competition, is a *score system*. Groups are assigned points after each round based on how close their answers are to being correct. This score accumulates throughout a complete game. The better the groups perform, the better the reward they get, as the score is based on performance. This principle follows one of the main takeaways presented in Wang and Sun's article, that better player skill should lead to an increased reward.

Another less obvious reward is that new images and themes are revealed to players as they play. A teacher chooses a theme at the start of the game, knowing which images the students will play. From a player's perspective, they do not know which images and themes they will play and look forward to seeing content they possibly recognise. While this effect is simply a result of the game featuring different themes with multiple images, Wang and Sun argue that gradually revealing new content can reward players.

While *experience points and levels* and *achievement systems* would also be fitting for Escapade, these have been omitted from the initial design due to scope concerns. We discussed the possibility of players levelling up in different roles as they play them - a player could be an experienced, high-level explorer but still new to the expert roles. Achievements could reward skilful play, like perfectly guessing a year, or persistence, like completing ten rounds. Ultimately we decided against both of these systems as they would expand the scope of the project significantly due to the need to save information between play sessions, preferably through the creation of user accounts.

Finally, as described in the *Clear Goals and Feedback* part of Section 20.3, players will be presented with *feedback messages* showing the result of their guess as soon as they submit it. This result might make players look forward to submitting their guess, as it might reward them with a high score, creating satisfaction upon submitting a guess and anticipation leading up to this moment. There is also an animation of accumulated points for each round to build anticipation further.

20.5 Learning by Design

Gee's article on learning and game design brings three highly relevant categories for Escapade. This section will describe principles applied in Escapade from the three categories, empowered learners, problem-solving, and understanding.

20.5.1 Empowered Learners

The principle about *identity* is implemented through cosmetic character creation and name selection, as illustrated in the user interface in Figure 19.5. This principle is also related to Malone's extrinsic fantasy factor discussed in Section 20.2. Combined with role selection, students can play fictional characters, taking on a new identity. This new identity is intended to help encourage deeper investment in learning and for the player to gain a sense of ownership of their character.

Escapade also allows for *distributed knowledge*. Gee uses distributed knowledge to explain a link between the player providing knowledge to a game character to succeed in the game. In Escapade, the explorer can't solve an image without player input. Furthermore, integrating the roles of the other experts on the team with the explorer is vital for success.

20.5.2 Problem Solving

Escapade utilises the principles *cycles of expertise, fish tanks*, and *skills as strategies* to achieve a constructive form of problem-solving.

The first time playing Escapade may naturally be challenging due to lack of experience. However, this allows for *cycles of expertise* in the game. By continually playing and getting better, players will increase their grasp of the game. An example is the wiki-banks. As players become more familiar with each expert role, they become better at supplying the explorer with useful information resulting in better scores.

To ease in players at the start of the game, *fish tanks* is another principle that Escapade uses. This principle is applied in the form of tutorials in the game. The game always lets the teacher select a tutorial as a theme when creating a game. Tutorials will be recommended for new players and will provide players with a breakdown of the game's core mechanics. The UI for choosing to play a tutorial is shown in Figure 19.4.

Finally, Escapade implements the principle of *skills as strategies*. This principle is related to cycles of expertise in how players will experience the skills they learn in the game. Supplying information to the explorer, for example, will become increasingly efficient with increased experience among the players.

20.5.3 Understanding

Escapade will also aim to increase the player's understanding of the principle of *system thinking* and *meaning as action images*.

System thinking is about seeing the bigger picture. This thinking is related to the previous principle of skills as strategies. The difference is that system thinking supplies players with the feeling that things they learn will be beneficial in the game and their education. Students can experience the connection between learning about elements from an image and deducing information like place and time. Ultimately, students should feel a sense of accomplishment towards the usefulness of cooperation and the learning fields of history and geography.

The following principle regarding *meaning as action image* focuses on the theory that people learn better through experiences. This principle is implemented in Escapade through interaction between the different roles. Since Escapade is an interdependent game, the interaction between players strengthens. This result creates a stronger sense of ownership of their role, immersing their experience and increases learning outcomes.

20.6 LEAGUE Framework

As we pointed out in Chapter 12, we have not opted to fully evaluate our concept using the LEAGUE framework but will rather use its factors and sub-factors as guidelines for our design. This section will handle LEAGUE's dimensions one by one and describe what means we have employed to address some of the factors in each dimension. Factors are mentioned in **bold** for easy identification. A full overview of the dimensions, factors, and sub-factors of LEAGUE can be found in Figure 12.1.

20.6.1 Learning

Escapade's intended **learning outcome** is knowledge enhancement among students by encouraging discussion of the curriculum among students. The jigsaw method is a specific **learning strategy** the game will employ to enable an active learning process, as described by constructivist theory. Social constructivism is especially relevant as a learning theory here, as instructional support (scaffolding) should be provided to other students by the various experts of the group.

20.6.2 Environment

To try to make sure Escapade **meets technical requirements and specifications** and avoid **technological related issues**, we have chosen a relatively simple form of a multiplayer game with minimal real-time communication between players' computers necessary. Escapade will also be a browser game with no advanced 3D graphics, giving us more time to build a multiplayer system robust enough to be tested by students.

20.6.3 Affective Cognitive Reactions

Our prestudy for this project includes multiple articles, *GameFlow* [29] (see Chapter 9) and *What Makes Things Fun to Learn* [27] (see Chapter 8) that directly relate to **enjoyment** in video games and educational video games, respectively. Chapter 10, which describes game reward systems, should help increase students' **motivation**. Some of the sub-factors of **engagement** (Immersion, Control and Challenge) are also directly covered in the articles mentioned. Previous sections in this chapter describe how all of these articles have been applied to our game design.

20.6.4 Game Factors

To bolster Escapade's **narrative**, we decided to include a basic story about a player having been sent back in time. This story was originally not a part of the game's design. Still, we decided to add it to the final design due to a basic narrative element being recommended by multiple articles in our prestudy, such as LEAGUE (where it shows up as a factor in-game factors). The game also features **game resources** like a tutorial and player customisation.

20.6.5 Usability

The principles outlined by **Jakob Nielsen's heuristics** in his *Usability Engineering* book were utilised for the usability aspect of the game [79]. These principles include following platform standards regarding the look of UI elements (consistency) and a clean, uncluttered, minimalist layout (screen design).

20.6.6 User

When picking a target audience for an educational game, picking a group where almost everyone has experience with video games makes it likely that players play and enjoy video games to some degree. Experience and personality (which includes preference) are part of what makes up

the **learner profile** factor, and our choice of target group likely helps constitute a fit between this factor and our game. Furthermore, as already mentioned in the *Concentration* part of Section 20.3, we believe the game will be somewhat self-regulating, where players will automatically adjust the difficulty of their task to fit their cognitive load capacity (a sub-factor in **cognitive needs**).

20.7 Summary

This chapter has expanded upon the description of Escapade, our chosen game concept, given in Section 17.6. We have described how the articles, studies and books presented throughout Part II have influenced the game's design. The next chapter will outline basic requirements that constitute the core functionality of Escapade, as well as requirements expected of the finished game.

Chapter 21

Requirements Specification

This chapter presents functional, and quality attribute requirements for Escapade. The requirements are created and developed based on rationale from Chapter 20, and are tested and validated in Chapter 25.

21.1 Functional Requirements

We will first specify the functional requirements (FR) divided into *host* and *players*, as there are two different user flows, as described in Section 19.1.

The FRs are also categorised by low, medium, or high priority. High priority FR are essential for the game to be played as intended. We should implement medium priority FR if we have enough time, but they are not fundamental for Escapade. Low priority FR are nice features but not deemed to impact the game very much. These low-priority FRs should be considered for future work.

Functional Requirements for the host

Table 21.1 describes our chosen functional requirements that we developed for the *host*.

ID	Description	Priority
FR1	The host should be able to create a game that players can join via a displayed game code	High
FR2	The host should be able to choose between various themes containing a set of rounds	High
FR3	The host should be able to choose a Tutorial theme	High
FR4	The host should be able to set a time limit for each round	Medium
FR5	The host should be able to set whether players can join teams at will or are assigned automatically	Low
FR6	The host should be able to set whether players can pick role at will or assigned automatically	Low
FR7	The host should be able to kick players from the lobby before the game starts	Low
FR8	The host should be able to navigate between lobby states (overview of all players and team select)	High
FR9	The host should be able to view the progress of all teams with information such as team members, points, and status	High
FR10	The host should be able to create their own themes	Low

Table 21.1: Functional requirements for the host

Functional requirements for the players

Table 21.2 shows our chosen functional requirements that we developed for *players*.

ID	Description	Priority
FR11	Players should be able to join a game with a game code	High
FR12	Players should not be able to join a game after the game has started	Medium
FR13	Players should be able to customise their character (avatar and name)	Medium
FR14	Players should be able to view all players in a game	Medium
FR15	Players should be able to join a team, and view team members	High
FR16	Players should be able to change teams	Medium
FR17	Players should be able to pick one role	High
FR18	Players should be able to change roles in role selection view	Medium
FR19	Players should be able to start a game when everyone is ready	High
FR20	Players with the explorer role should be able to view an image and related tasks	High
FR21	Players with the explorer role should be able to interact with the tasks (select multiple-choice alternative, pick a date, pin location on an interactive map)	High
FR22	Players with the explorer role should be able to submit answers for the team	High
FR23	Players with the expert role should view a wiki-bank of information depending on their field of expertise	High
FR24	Players with the expert role should be able to navigate the wiki-bank with an interactive table of contents	Medium
FR25	Players should be able to view the time left for the current round	High
FR26	Players should earn points depending on their answers	High
FR27	Players should be able to view the total score after the game is over	High
FR28	Players should be able to view the top 3 teams after a game is over	Medium

Table 21.2: Functional requirements for the players

21.2 Quality Attribute Requirements

Table 21.3 shows the quality attribute requirements chosen for the game. Especially important in this project are the *modifiability* and *availability* quality attributes. Modifiability represents a central part of the game's design, being able to add new or edit game themes easily. Such a property also allows for rapid prototyping of new content throughout development. Availability is important as our time to conduct our experiment is limited by the time slots we have been assigned in the two classes we will be testing in. While the game does not need to be completely bug-free (it is a prototype, after all), experiencing issues that would cause significant disturbance to the game experience for players or cause game sessions to stop would be detrimental to the project result.

Usability is also added to have a minimum requirement for intuitiveness in the game. We decided not to have a prerequisite of including an extensive tutorial but instead combine it with instructions before going into a game (QA7). The benefits of this decision are freed resources in terms of player testing and development efforts.

ID	**Description**	**Category**
QA1	The real-time database should be available 95% of the time	Availability
QA2	The game should run without any bugs that take more than 30 seconds to fix	Availability
QA3	Developers should be able to create and use a new game theme within 15 minutes	Modifiability
QA4	Developers should be able to edit text, images, and settings in a theme within 5 minutes	Modifiability
QA5	It should take no longer than 5 seconds for users to be sent to the next round when a team submits their answers	Performance
QA6	It should take no longer than 5 minutes for users to join a game, create a character, and join a team	Usability
QA7	After receiving instructions, it should not take longer than 20 minutes to play the tutorial and understand how to navigate the game	Usability

Table 21.3: Quality attribute requirements

21.3 Summary

This chapter presents a list of functional and quality attribute requirements. These requirements are influential for the next chapter, which describes which technologies we chose for developing the prototype of Escapade. We will also test and validate all requirements in Chapter 25.

Chapter 22

Chosen Technologies

This chapter will introduce the selection process and chosen technologies based on the technologies reviewed in Chapter 16 and was part of the specialisation project [9]. Additionally, sections on Sanity and Google Maps Platform have been added.

22.1 Selection Process

Chapter 16 described relevant technologies for game development. This project requires three main technology categories, which we will use to develop our game further. These categories include a design tool, a game development solution, and a backend solution. Escapade is a browser-based game for desktop, tablets, and mobile devices. It does not require any game or physics engines, making a web solution with responsive web design favourable. As a convenient way of improving responsiveness for multiple screen sizes, including a CSS framework will be helpful. In the case of a backend solution, we decided upon using BaaS solutions primarily because of limited development time.

The first step was to pick a suitable design tool, a web framework and a CSS framework, and BaaS providers. We based our choices on three criteria, *game requirements*, *maturity* and *development experience*.

The technologies we choose should support the game requirements outlined in Chapter 21. Furthermore, maturity is essential in having stable solutions, finding documentation, and receiving support if needed. Lastly, development experience is important as time is a significant bottleneck for our project. Prior experience of technologies is thus influential as previous experience with a tool can increase development efficiency.

Based on these three integral factors, we decided upon *Figma* as a design tool. *React* as a web development framework, with *Tailwind CSS* as a supporting CSS framework. *Firebase* and *Sanity* were chosen as BaaS providers. *Google Maps JavaScript API* was also added as a map integration towards our React application.

22.2 Figma as a Design Tool

Figma is an online web-based collaborative design tool that allows multiple people to work on the same project [80]. There exist numerous design tools for rapidly designing applications, like Adobe XD or Sketch. However, the choice ultimately fell on Figma based on our three criteria.

Game Requirements

Escapade requires a set of views for the different requirements like creating a room and having a lobby. Figma has all the functionalities like adding text, buttons, and UI elements to develop wireframes and prototypes to visualise our ideas. Figure 22.1 shows an example of a low-fidelity wireframe of a view in the game.

Maturity

Figma has been around since 2016 and has since then become one of the most popular design tools with customers like Dropbox, Airbnb, and Microsoft [81]. There are a lot of helpful resources online if needed. Additionally, unlike other tools like Sketch, Figma is free to use, which is a bonus.

Development Experience

We both have experience using Figma from earlier projects. Creating low-fidelity wireframes of views, then iterating towards a high-fidelity wireframe with added detail with elements like colour, is a workflow we were comfortable with.

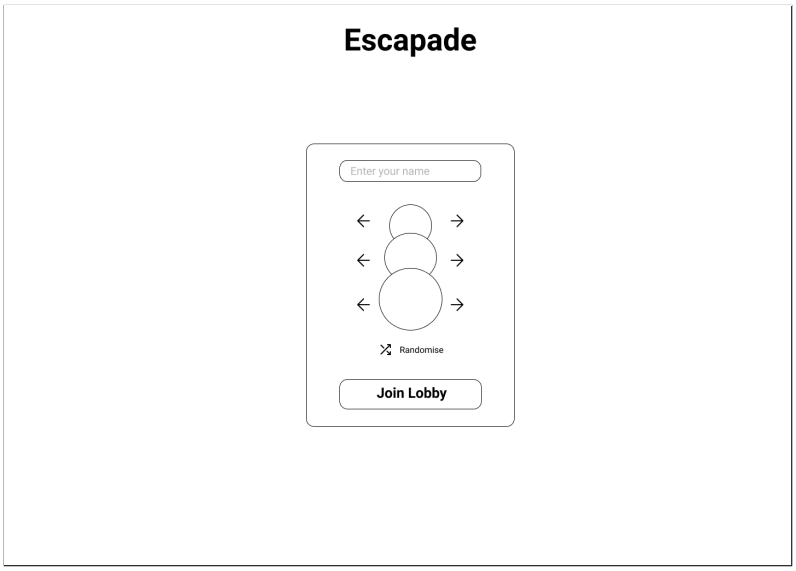


Figure 22.1: Example of a low-fidelity wireframe using Figma

22.3 React and Tailwind CSS as a Web Development Solution

React is an open-source JavaScript library developed and maintained by Meta [82]. Other similar popular web frameworks include Vue and Angular. Tailwind CSS is a CSS framework that focuses on utility. There are plenty of other frameworks to ease the styling of web pages, like Bootstrap and SCSS. React with TypeScript and Tailwind CSS were chosen based on our evaluation criteria.

Game Requirements

The game requirements of Escapade are feasible to solve using most web development solutions. Most modern JavaScript web frameworks and libraries support third party modules and integrations to the backend that would fit our game requirements [83]. Additionally, React supports TypeScript as a programming language, improving factors like better readability and maintainability over standard JavaScript. Tailwind CSS was assessed to suit our need for user interface styling by simplifying the CSS coding process as we had used this framework before.

Maturity

React has been around since 2013, has a large user base, and has thorough documentation. This library is mature, with a widespread online community for support. Tailwind CSS includes an extensive documentation page and has a large online community [84].

Development Experience

As with the case of choosing a design tool, React is also a library that we have used previously. Using React has been a straightforward and efficient form of development, which has ultimately skewed our choice in its favour. We also decided to use TypeScript with React mainly for better readability and error highlighting. TypeScript is also a programming language we are comfortable with. We had prior experience with Tailwind CSS, which is designed to make CSS writing fast, which is optimal for our development resources.

22.4 Backend as a Service

This section describes Firebase and Sanity as our solutions for BaaS. Firebase is provided by Google, supporting data storage, hosting, cloud functions, and more [85]. Other options we could consider are AWS Amplify and Azure Mobile Apps. Firebase provides two database solutions relevant for us, Cloud Firestore and Realtime Database. The choice fell on Cloud Firestore as that is Firebase's newest database that builds upon the Realtime Database. Cloud Firestore also supports real-time functionality, which was the most important criterion [86].

Section 21.2 described one crucial requirement for our game, which is *modifiability*. Game data, like images, questions, and wiki banks in Escapade, needed to be modifiable to allow us to create and edit content. One solution could be to create a Content Management System (CMS) in React to upload game data; however, this would require considerable development time. Ultimately, Sanity was decided upon as the solution to this problem.

22.4.1 Firebase Cloud Firestore

Cloud Firestore is a NoSQL document-based database that provides simple and scalable data storage [87]. A NoSQL document-based database, unlike a relational database, is created to have a more flexible structure. This structure makes it easier for developers to create queries in the web application similar to its database queries. This service is also integrated with other Firebase solutions like hosting, making the choice even more favourable.

Game Requirements

Escapade includes requirements where multiple players and a host should be able to write and read game data simultaneously. Cloud Firestore provides this real-time functionality.

Maturity

Firebase was acquired by Google in 2014 but was first founded in 2011 [85]. Since then, the service has become known for its ease of use, with big companies like Duolingo and Alibaba using its services [88]. Using React with Cloud Firestore is also a common combination, making finding documentation and support online easier [89].

Development Experience

A BaaS aims to reduce development time by letting developers focus on the frontend application. Firebase also provides hosting, which is easily integrated into any Firebase project. Finally, Firebase's ease of use and our prior experience with Firebase made this choice better for our usage.

22.4.2 Sanity

Sanity differs from a traditional CMS like WordPress or Squarespace by being "headless". A headless CMS creates a way of providing authored content to our web application as data over an API [90]. Sanity has its datastore connected to our platform, called Sanity Studio. This platform allows us to create content and serve this in JSON format to our React application, reminiscent of how we fetch data from Cloud Firestore.

Game Requirements

Sanity provides an easy way to create and edit game data which is noteworthy for modifiability in Escapade. Sanity is also flexible, with the data structure we author determined by code, described further in Section 23.3.

Maturity

Sanity has been available since 2015 [91]. It is used today by prominent companies such as Figma, Nike, and National Geographic. Sanity provides documentation, making it easy to get started and find support if needed [92].

Developer Experience

Sanity adds value to our game by eliminating the need to create our custom solution to create similar functionality. It utilises JavaScript, which is familiar and easily integrated into a React

application. Sanity also stores our data and hosts a ”Studio” for us, improving ease of use.

22.5 Google Maps JavaScript API

Google Maps Platform, Mapbox, and Leaflet were alternatives worth considering when choosing an API for maps. Google's solution is the most well known of these, with cons that include being more expensive than the other options [93, 94, 95]. However, as Escapade is a prototype, the included credits are more than enough, making this choice convenient. The Google Maps Platform API of choice is the Maps JavaScript API, supporting TypeScript.

Game Requirements

One of the functional requirements in Escapade is to use an interactive map to pick a location. The Maps JavaScript API includes all needed functionality, such as navigating around a map and pinning a location.

Maturity

The Google Maps Platform is the most used maps service with a vast library of mapping data. As there are many users, there naturally exists a lot of documentation, making the platform easy to use.

Developer Experience

Many integrated packages make it easy to connect Map JavaScript API to our React application. A solution like this is convenient as we have no prior experience implementing a map into an application.

22.6 Summary

This chapter presented our selection process for choosing technologies for Escapade. The selection process was based on three evaluation criteria: game requirements, maturity, and developer experience. We decided to use Figma for creating wireframes and prototypes. Then we chose React and Tailwind CSS for a web solution. Firebase, or specifically Cloud Firestore, was selected as a BaaS database solution, including Firebase Hosting as our hosting solution. We chose Sanity as a CMS solution to add and manage game data. Finally, we selected Google Maps Platform to allow players to use an interactive map in the game.

Chapter 23

Software Architecture

This chapter will discuss the overall architecture in creating Escapade, presenting technical relations between the frontend and backend of the system. Afterwards, we will describe each part of the system more thoroughly, including design patterns for our React application.

23.1 Architecture Overview

The architectural overview of Escapade is depicted in Figure 23.1. Escapade's frontend and backend are based on a *client-server* pattern [96]. The client-side consists of a React web application, while the server-side uses Cloud Firestore and Sanity. The server side communicates with multiple client-side users. Cloud Firestore is utilised as a database for storing and fetching *player* data in the game in real-time. At the same time, Sanity serves *game content* data from a custom content management system. The client-side also uses Google's Maps API for fetching map data.

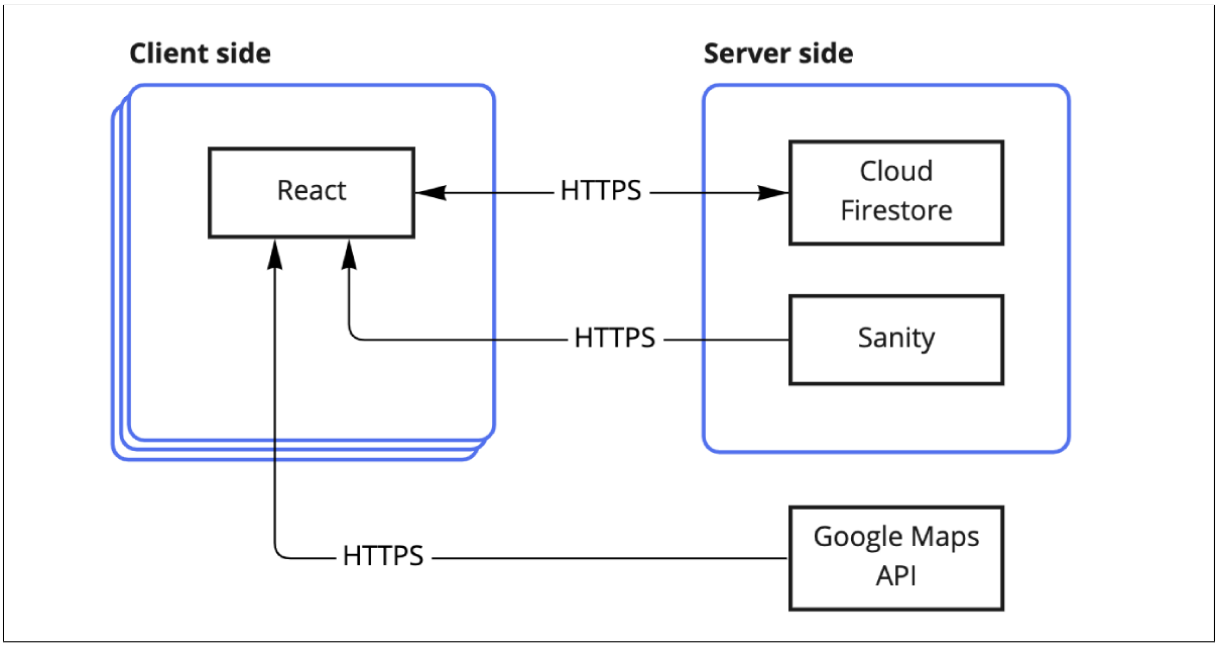


Figure 23.1: Architectural overview of Escapade

23.2 Cloud Firestore

Cloud Firestore uses a document database structure. This structure results in the database architecture differing from a traditional relational database. Each game in Escapade is stored as a document in a collection. Furthermore, each document contains a set of key-value pairs, exemplified in Appendix A. However, to understand the database structure, we will utilise an entity-relationship (ER) diagram to have an overview of the relations. For each game, there are multiple participants, and each participant can be part of numerous rounds. This ER diagram is illustrated in Figure 23.2. It is worth noting that the diagram is not a direct translation of the relations in a document-based database.

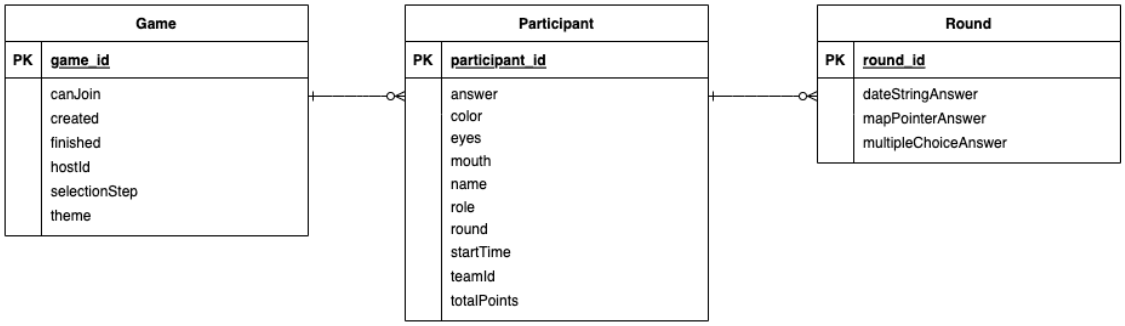


Figure 23.2: Cloud Firestore database entity-relationship model

23.3 Sanity

As described in Section 22.4.2, game data is created through Sanity Studio. Sanity works like a database for the game data, which is then served to the client as an API endpoint. The platform is divided into three categories when accessing Sanity Studio: list, document list, and document. Figure 23.3 shows an example of Escapade's Sanity Studio. Adding a document in this example is the same as adding a new theme. As an additional note, in this figure, *maps* refers to a *theme* in the game.

Content in Sanity Studio is structured through *schemas*. A schema creates document types that define a document with multiple fields. Escapade consists of two document types, one for themes (maps) and one for wiki banks. For instance, a *theme* document type is created by a schema that includes multiple fields like name, id, description, and rounds. A JavaScript code

example of the schema is displayed in Appendix B.

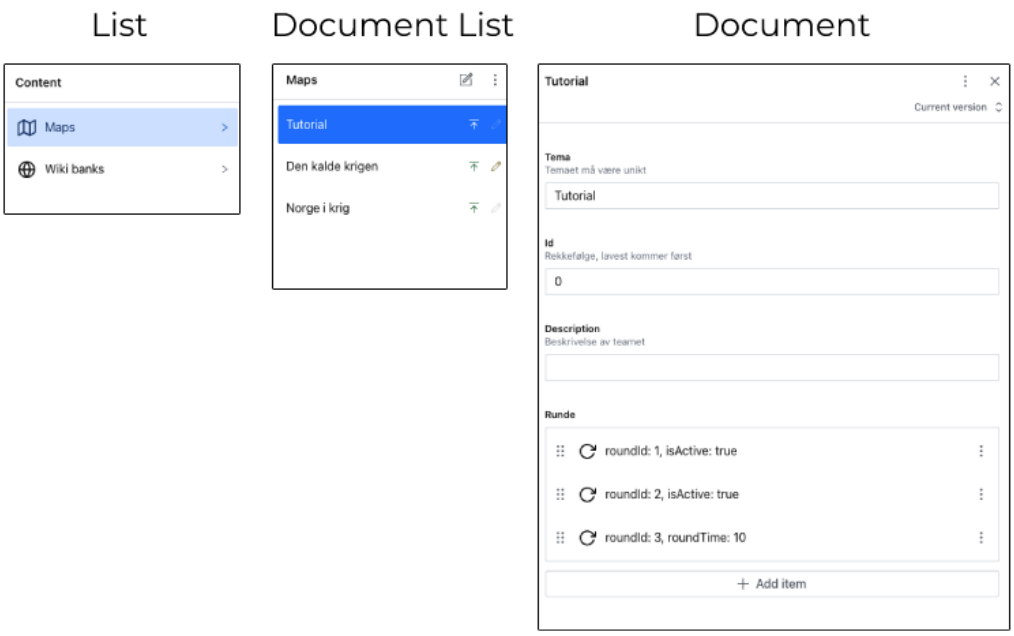


Figure 23.3: Sanity Studio content manager

The game data authored by us is stored by Sanity in their database. An entity-relationship diagram is illustrated in Figure 23.4 to gain a simplified overview of the structure and relations in the *theme* document. It is worth noting that this ER diagram is not a direct translation of how data is stored in Sanity. This figure shares some similarities to the Cloud Firestore ER diagram in Figure 23.2 as Sanity provides game data and answers while Firestore handles the same data.

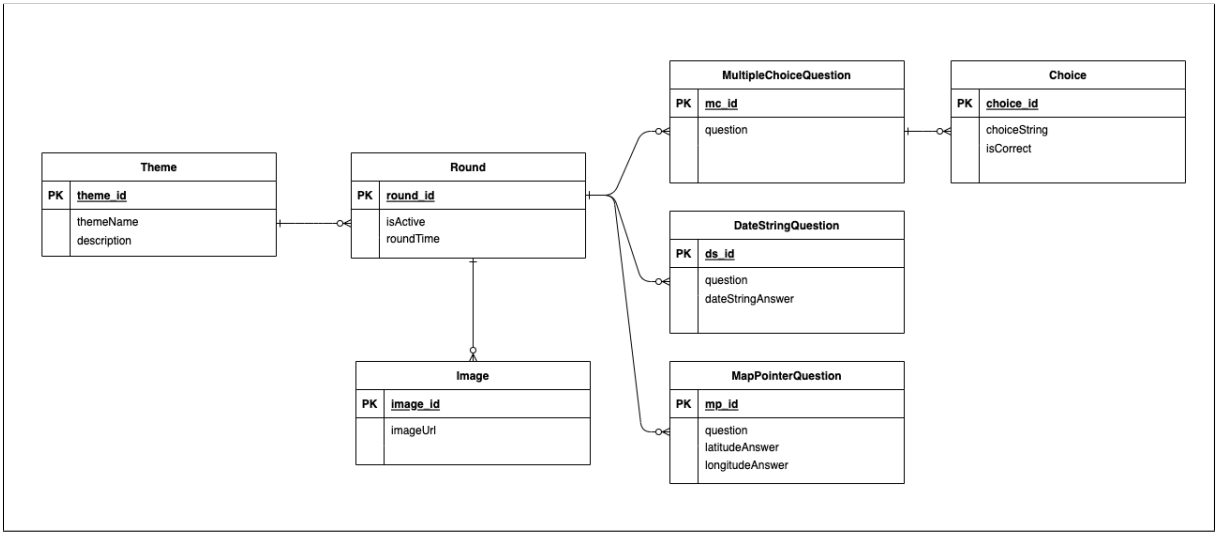


Figure 23.4: Sanity database entity-relationship model for a document

23.4 React Architecture

React is an unopinionated library; there is no correct or wrong way of structuring a React application. Our application is mainly divided into *components*, *contexts*, *helpers*, and *views*, for global state management. We also use *hooks*, which simplifies local state management and other React features without writing a class. For instance, the *useEffect* hook function is used instead of the previous React class lifecycle methods [97].

Figure 23.5 shows an overview of our file structure in React. Components are the building blocks of Escapade and are structured by folders. Folders are created to categorise components depending on the game elements. The *shared* folder is used for components that are shared between multiple views or components. Most components, for instance, avatar.tsx, header.tsx, and mapComponent.tsx can be reused. A few components may not be reused but are used to simplify the code and decouple it from the views. Most components also handle logic, for example, calculating scores. Additionally, some components communicate directly with the server-side.

Global state management is an integral part of a React application to avoid prop drilling, i.e. passing data via props through a hierarchical tree of components, which can be cumbersome. Our chosen solution for easier sharing of data among components is *React Context* [98]. Data is stored as states in the *context/* folder and accessed as hook functions in components.

Helpers are simple reusable functions that we may use globally in the application. These functions handle connections to Cloud Firestore and Sanity and logic such as game code generation or date conversion.

Views in Escapade construct the user interface the clients see and can be revisited in Chapter 19. All views use components from the *components/* folder. Some views also handle communication with the server-side and pass data to components. There are three categories of views, one for players, one for hosts, and shared views.

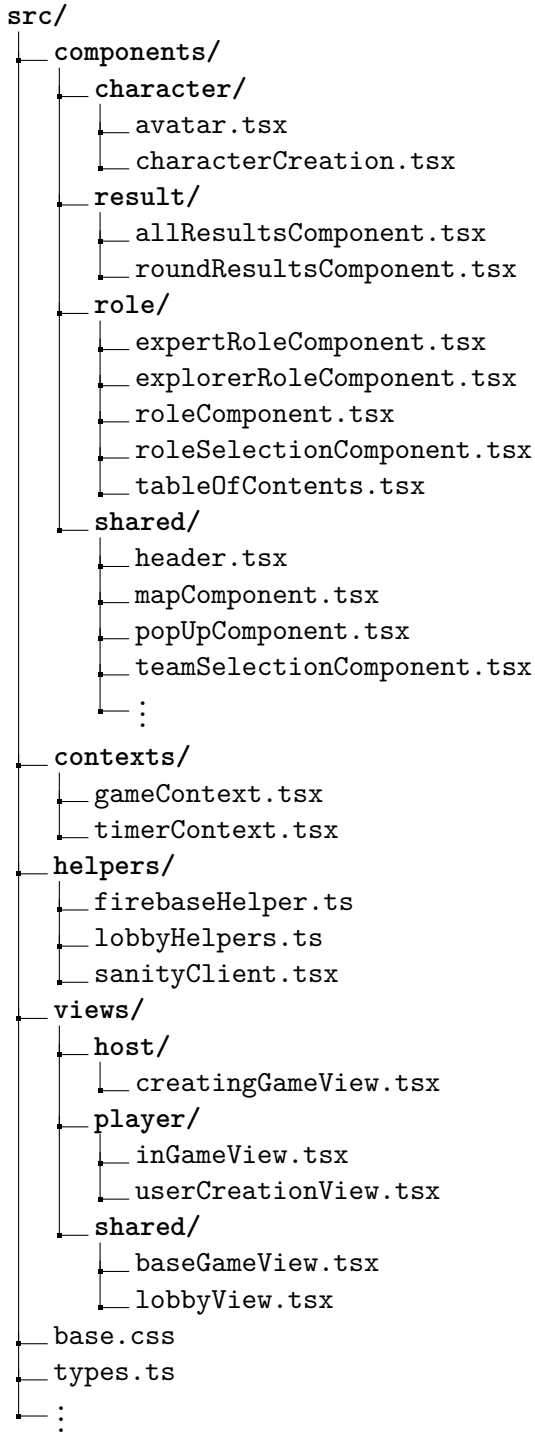


Figure 23.5: React file structure

23.5 React Design Patterns

The architecture of Escapade's client-side is designed with several design patterns. We will thus base the usage of these patterns on the React application. These design patterns can be divided into *creational patterns* for creation mechanisms, *structural patterns* for keeping

structures efficient and flexible, and *behavioural patterns* for how components behave among each other [99].

23.5.1 Creational Patterns

In React, a *factory pattern* helps create components that differ depending on parameters while removing overhead logic for each creation. This pattern is helpful when fetching data from Cloud Firestore or Sanity. Having components that visually change based on data from the server-side maintains a factory frontend code, creating new instances based on dynamic data. The factory pattern is used in Escapade, where fetched user data changes, such as in lobbies where users are rendered with various avatars and names.

Escapade also benefits from a *Singleton pattern* in conjunction with React Context. A Singleton ensures that a global instance is accessible throughout the whole application while only being able to be instantiated once. This behaviour is used in Escapade through React Context. A context is created and wrapped around the application, creating one instance and allowing variables to be used in a way that is global amongst components while being read-only and only changeable through its accompanying function. In Escapade, this is, for example, used for keeping track of the timer in the game.

23.5.2 Structural Patterns

The *bridge pattern* is a convenient pattern that we can use in React projects. This pattern is about decoupling how a component works (abstraction) from the visual aspect of the component (implementation). For example, we can develop the visual representation and the function of a button independently of each other. In Escapade, components like buttons and modals use this to keep the components clean and understandable.

23.5.3 Behavioural Patterns

As events in Escapade are happening in real-time, the *observer pattern* is crucial to adopt. This pattern adds a subscription mechanism to notify about any events that occur to components being observed. This pattern is used for all actions and events that demand real-time updates, such as lobby components, submission components, and progress components.

A *command pattern* is also utilised in this prototype. This pattern encapsulates multiple requests into one object with data from all requests. Instead of writing to the database for each player's

actions, they are transformed into one object and sent to the database. This technique drastically reduces the number of database transactions to Cloud Firestore.

Another prominent design pattern is the *state pattern*. The idea behind this pattern is that whenever a component changes its internal state, its behaviour also changes. There are multiple occasions where this is used in Escapade. For example, there are various rounds with different images and questions in a game of Escapade. Rounds consist of the same components in the React code, but their internal state is modified after each round. The resulting content of each round will also change based on the new internal state.

23.6 Summary

This chapter described the architecture for Escapade, which is based on a client and a server-side pattern. The client-side consists of a React web application that communicates with the server-side, consisting of Cloud Firestore and Sanity. The React application also fetches map data from the Google Maps API. The client-side also utilises multiple design patterns, divided into creational, structural, and behavioural patterns. Software architecture is an integral part of the game development process that we will describe further in the next chapter.

Chapter 24

Game Development Process

The first 11 weeks of the project were dedicated to developing a prototype of Escapade based on our specialisation project [9]. This chapter describes the process of creating the prototype of Escapade.

24.1 Development Methodology

After we constructed our game concept (see Chapter 18), the game itself was ready to be developed. Figure 24.1 gives us an overview of our methodology from the idea to the development phase. This figure serves as a framework for our methods. It is worth noting that this process is not rigidly linear, resulting in an iterative process.

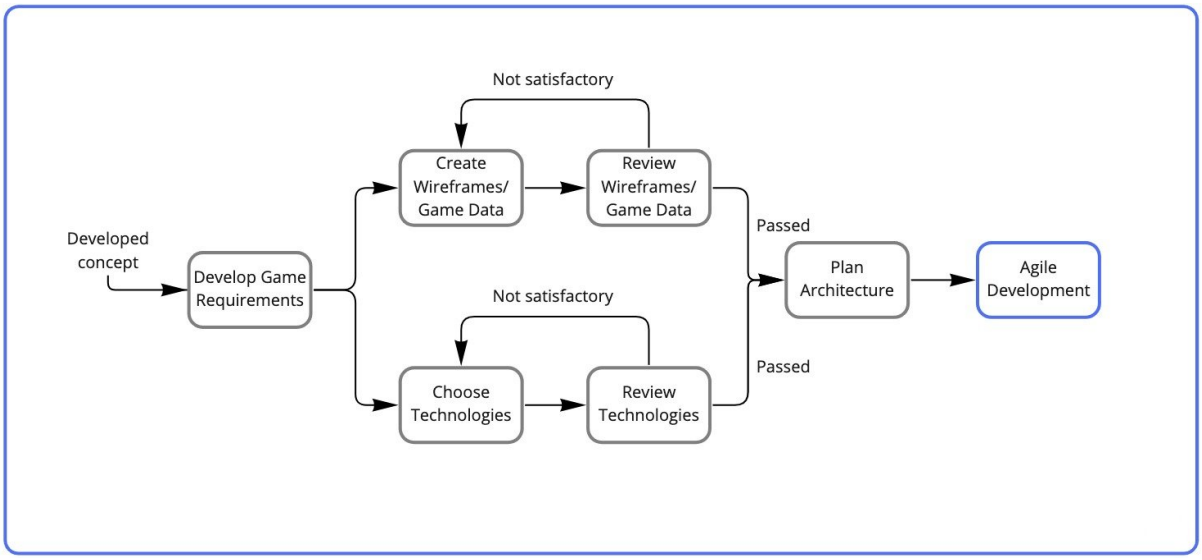


Figure 24.1: Overview of development methodology

The process started with developing game requirements, both functional and non-functional (see Chapter 21). These requirements built the foundation of the game. We continually designed wireframes and game data and determined technologies that fit this foundation. Low-fidelity and high-fidelity wireframes (mockups) were made of user interfaces in the game, while game data concerns content like images, questions, and wiki banks. Figure 24.2 and Figure 24.3 shows an example of a result of our iterative process for wireframing. These parts of the prototype were regularly reviewed and tested by friends and peers that were not a part of the test group.

We also tried and verified technologies to work for our needs. As all aspects gradually came together, we continued with planning the software architecture and preparing for coding the prototype, where we benefited from an agile development process.

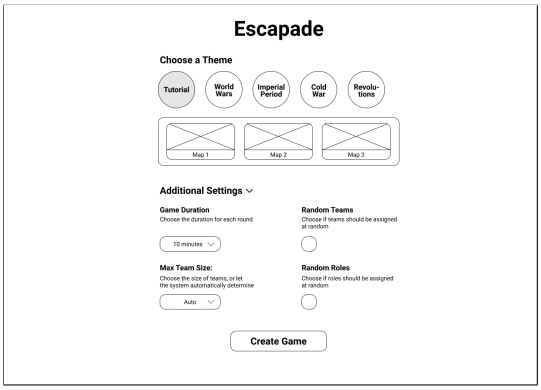


Figure 24.2: Low-fidelity wireframe

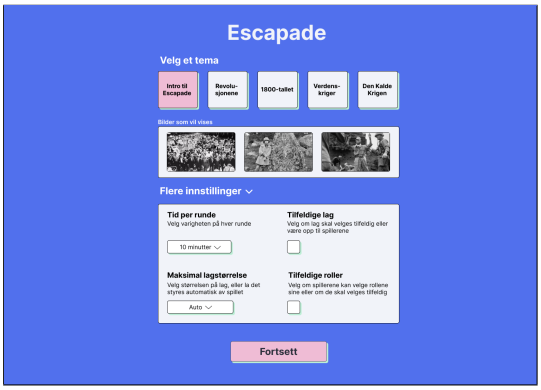


Figure 24.3: High-fidelity wireframe

24.1.1 Agile Development

An agile development process is an iterative approach where the team works in small increments, naturally supporting quick adjustments [100]. Such an approach fits our development methodology as issues are bound to appear quickly with our limited game development experience.

To start, we determined to use Github as our versioning control system and collaborative tool, based on earlier experience. Github also provides a Kanban board connected to a code repository. A Kanban board is a popular agile framework that allows us to communicate task progress and status in a team. Figure 24.4 displays an example of our Kanban board during development. Tasks in our board are categorised and divided into ”To-do”, ”In progress”, ”PR” (Pull Request, or review phase), and ”Done”. Coupled with this board, we also utilised some elements from Scrum like daily stand-ups and sprints.

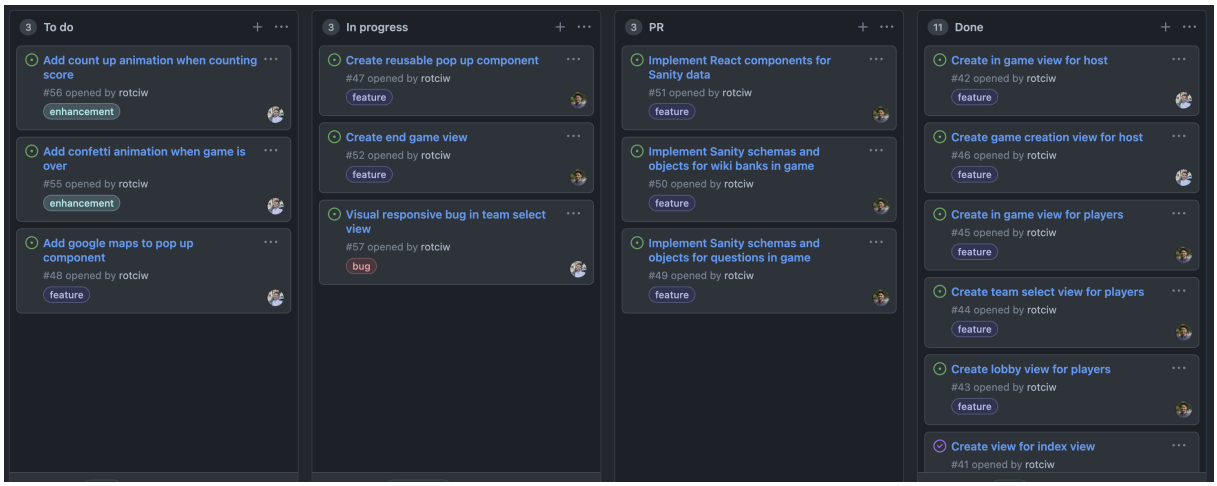


Figure 24.4: Screenshot of our Kanban board

To avoid later complications in our code, we agreed on coding conventions and to utilise linters in our integrated development environment (IDE). We based it on Airbnb's Style Guide [101] for coding conventions and adjusted it to fit React with TypeScript code. Another agile principle we use is continuous integration and deployment (CI/CD) through Github Actions. When code is reviewed and accepted, it will automatically be pushed to our Firebase hosting solution.

With the nature of the project being time-restricted, we determined not to implement testing of the code in this project. The decision was based on our goal of making a prototype and not a completely developed game. The focus was to implement as many game features as possible with limited time.

24.2 Summary

In this chapter, we described our game development process and tools. We provided an overview of our methodology and described how we utilise agile development. A well-defined development process has helped create a prototype in time.

Chapter 25

Test and Validation of Requirements

In this chapter, the functional and quality attribute requirements from Chapter 21 will be tested and validated to see if Escapade meets its requirements. This test and validation are substantial to ensure that our game has a suitable quality to be used in the experiment.

25.1 Functional Requirements

This section describes which functional requirements are implemented in Escapade. The partially implemented or not implemented requirements are commented on below the tables.

Functional Requirements for the host

Table 25.1 provides an overview of the functional requirements that we implemented for the *host*.

ID	Description	Priority	Implemented
FR1	The host should be able to create a game that players can join via a displayed game code	High	Yes
FR2	The host should be able to choose between various themes containing a set of rounds	High	Yes
FR3	The host should be able to choose a Tutorial theme	High	Yes
FR4	The host should be able to set a time limit for each round	Medium	Partly
FR5	The host should be able to set whether players can join teams at will or are assigned automatically	Low	No
FR6	The host should be able to set whether players can pick role at will or assigned automatically	Low	No
FR7	The host should be able to kick players from the lobby before the game starts	Low	Partly
FR8	The host should be able to navigate between lobby states (overview of all players and team select)	High	Yes
FR9	The host should be able to view the progress of all teams with information such as team members, points, and status	High	Yes
FR10	The host should be able to create own themes	Low	Partly

Table 25.1: Functional requirements for the host.

For the host side, we implemented all high priority requirements. None of the low priority requirements were fully implemented, as these requirements were deemed not to be critical for the gameplay. We also determined to control the host user flow during the experiment. This choice signified that FR4, FR7, and FR10 could be accessed by us manually through Cloud Firestore and Sanity, hence why they are marked as partly implemented. FR5 and FR6 were

part of settings that would be nice but not crucial for our research goals.

Functional requirements for the players

Table 25.2 shows an overview of functional requirements that we implemented for *players*.

ID	Description	Priority	Implemented
FR11	Players should be able to join a game with a game code	High	Yes
FR12	Players should not be able to join a game after the game has started	Medium	Yes
FR13	Players should be able to customise their character (avatar and name)	Medium	Yes
FR14	Players should be able to view all players in a game	Medium	Yes
FR15	Players should be able to join a team, and view team members	High	Yes
FR16	Players should be able to change teams	Medium	Yes
FR17	Players should be able to pick one role	High	Yes
FR18	Players should be able to change role in role selection view	Medium	No
FR19	Players should be able to start a game when everyone is ready	High	Yes
FR20	Players with the explorer role should be able to view an image and related tasks	High	Yes
FR21	Players with the explorer role should be able to interact with the tasks (select multiple-choice alternative, pick a date, pin location on an interactive map)	High	Yes
FR22	Players with the explorer role should be able to submit answers for the team	High	Yes
FR23	Players with the expert role should view a wiki-bank of information depending on their field of expertise	High	Yes
FR24	Players with the expert role should be able to navigate the wiki-bank with an interactive table of contents	Medium	Yes
FR25	Players should be able to view the time left for the current round	High	Yes
FR26	Players should earn points depending on their answers	High	Yes
FR27	Players should be able to view the total score after the game is over	High	Yes
FR28	Players should be able to view the top 3 teams after a game is over	Medium	No

Table 25.2: Functional requirements for the players

All functional requirements for players with high priority were implemented when creating the prototype of Escapade. The majority of medium priority requirements were also implemented. Of all medium priority functional requirements, the ones which impacted the players we prioritised the most. FR18 was not implemented as it would only be a problem if all players in a team would pick a role without discussing it with each other before choosing. FR28 was not implemented because of time restrictions. We also deemed it sufficient to announce the top 3 teams manually during the experiment, as all teams were shown in the host progress view.

25.2 Quality Attribute Requirements

Table 25.3 presents tests of our quality attribute requirements. we took these observations from informal test sessions with other students before the experiment.

ID	Description	Category	Implemented	Comment
QA1	The real-time database should be available 95% of the time	Availability	Yes	No database downtime was observed at any time
QA2	The game should run without any bugs that take more than 30 seconds to fix	Availability	Yes	A few players had to refresh their browser to load the next round once the team submitted answers, but it took less than 30 seconds
QA3	Developers should be able to create and use a new game theme within 15 minutes	Modifiability	Yes	Adding a new gameplay theme in Sanity Studio takes a few minutes at most and is published within a few seconds
QA4	Developers should be able to edit text, images, and settings in a theme within 5 minutes	Modifiability	Yes	Editing a gameplay theme in Sanity Studio takes just a few minutes and is published within a few seconds
QA5	It should take no longer than 5 seconds for users to be sent to the next round when a team submits their answers	Performance	Yes	Redirects took less than 1-second
QA6	It should take no longer than 5 minutes for users to join a game, create a character, and join a team	Usability	Yes	All users successfully completed the listed tasks without additional guidance
QA7	After receiving instructions, it should not take longer than 20 minutes to play the tutorial and understand how to navigate the game	Usability	Yes	All users successfully played through the tutorial and understood how to navigate the UI after receiving a short introduction

Table 25.3: Quality attribute requirements test results

QA2 was the only quality attribute requirement that did not go perfectly. Most internal test subjects did not experience bugs, but a few had technical issues with game data not updating

between rounds. It was challenging to recreate the problem, but a quick refresh solved this issue when it appeared. We believed QA2 was sufficiently implemented for the experiment.

25.3 Summary

In this chapter, we present the test and validation results of the game prototype's functional and quality attribute requirements. This chapter wraps up Part III. The next part will detail the experiment where we test the prototype on real users.

Part IV

The Experiment

This part describes the project's experiment that was conducted in two upper secondary school history classes. We will outline the execution of the experiment, detail our data collection methods, and discuss the reliability and validity of the experiment.

Chapter 26

Execution of the Experiment

This chapter will cover the design and execution of the experiment conducted in this project, including the selection of participants. The purpose of the experiment as part of this thesis is to answer research questions that concern players' motivation, learning, enjoyment, and engagement, primarily focused on the game's collaborative elements (RQ2-RQ6). All research questions can be found in Section 3.2.

26.1 Participant Selection

Since the target audience for Escapade is upper secondary school students, finding relevant classes to test on was considered ideal. Our supervisor put us in contact with two history teachers at Kristen Videreående skole Trøndelag (KVT), who were willing to let us test the prototype. This type of participant sampling is known as *cluster sampling*, which is when a group of people who are likely representative of an experiment's population is already grouped [11]. In *Researching Information Systems and Computing*, Oates classifies cluster sampling as a probabilistic sampling technique, which indicates that it is likely that the sample is representative of the population being studied [11]. Opposed to this is non-probability sampling, which, at best, includes a weak bias compared to the population studied.

Another advantage of using upper secondary school classes was the ease of recruiting enough participants to regard our results as significant. Oates considers that a good rule of thumb for small-scale research projects is to have a sample size of at least 30, as a lower number than this means statistical analysis can be unreliable [11]. The total number of participants in our experiment was 36.

26.2 Experiment Description

We had two different classes of students to test on, and we experimented separately with each group on the 26th of April 2022 and the 4th of May 2022. After having presented ourselves and our project, we proceeded to give a walk-through of the game's user interface (UI). We had decided in advance that the game's usability would not be a point of focus during the experiment and, as such, decided to try to minimise the impact of potential usability issues

on the result. The presentation slides used when presenting the project and game have been included in Appendix C.

The participants were told to split into groups of three or four members and sit together around a table. Following this, we hosted a tutorial game. Players were then told to join a team together with their group members. The participants played through the tutorial rounds and were encouraged to ask questions about practical details if they found something confusing. For example, if they struggled with the game rules or had technical issues. After every group had finished the tutorial game, a ”real” game, with *the Cold War* as the theme, was hosted. Participants were once again told to join teams like last time. Some participants experienced bugs where a new image would fail to load once players finished a round, but this was quickly rectified by refreshing the browser. We got the impression that it did not significantly alter the gameplay experience for participants. After everyone had completed the ”real” game, the participants were directed to a questionnaire where they could describe their experience with the game. The data collection aspect of the experiment is described in the next chapter.

Examining the effect of the jigsaw method

As described in Section 20.1, an integral aspect of Escapade is that players in the same team are not supposed to look at each others' screens to take advantage of strengths in the jigsaw method [12]. Wanting to evaluate the effect of this element, we decided to execute the experiment slightly differently in the two classes. We presented the game as designed in the first class and instructed the participants not to look at each other's screens. For the second class, we encouraged participants to look at teammates' screens. Examining the differences in experimental results between the two classes can help quantify the effect of increased task interdependence in teams. This division will help us give a more nuanced answer to our research questions regarding the game's collaborative elements. As we advance in this thesis, the first and second classes will be referred to as the ”jigsaw class” and the ”non-jigsaw class”, respectively.

26.3 Summary

This chapter has described how this project's experiment was planned and carried out. It has also touched on the purpose of the experiment. The experiment was carried out in two upper secondary school classes during their history lessons, with students playing the game twice each. We gave the two classes slightly different instructions to examine the effect of the game's ”jigsaw method”-element.

Chapter 27

Data Collection

Chapter 4 described *questionnaire* and *observation* as chosen data generation methods to help answer our research questions. This chapter will further elaborate on our data collection methods. Additionally, it is important to recognise the data privacy ethics of gathering such data. A section on the privacy considerations of collecting data is thus included.

27.1 Data Privacy

Data privacy is a serious aspect of gathering and processing personal data for our Master's Thesis. The game does not save or collect personal data, but our questionnaire does. It was essential to create a transparent process where participants could trust us with their data. The first step was to report our data processing plan to NSD - Norsk senter for forskningsdata (Norwegian Centre for Research Data). This form included information on the personal data we would collect, test population, responsible persons, documentation, how data is processed, data security, and project duration. Our plan was approved by NSD 25th of February 2022.

Furthermore, at the start of the questionnaire, each participant received information with the same information we provided NSD before they could give consent. This material can be found in Appendix E. Sharing this information with participants is not only crucial but also a fundamental right that is rooted in Norwegian law [102]. Participants were also reminded of the option to withdraw from the experiment at any given time.

27.2 Questionnaire

Participants of the experiment answered a questionnaire of 15 statements and 11 questions. Statements and questions are grouped depending on their related research question. The questionnaire will be translated to English in this chapter but was initially in Norwegian (see Appendix D). The statements and questions have been reordered for readability in the following subsections.

All *statements* use a *Likert scale* ranging from "fully disagree" to "fully agree" as the response format. We chose this format to accommodate ordinal data collection that can be tested using the Mann-Whitney U test [17]. Additionally, statements from this questionnaire are based on

the research paper from Wang and Lieberot [61]. We have then iterated upon these statements. *Questions* however, use response formats like text, multiple-choice, and the Likert scale.

27.2.1 Statements Related to Motivation

Participants were presented with five statements regarding motivation, as shown in Table 27.1. The primary goal of these statements is to grasp how playing Escapade affects a player's motivation towards the subject (history), which corresponds to RQ2.

These statements address different stages of the experiment. S1 focuses on a player's motivation *before* the gameplay, S2 is directed on motivation *during* the game, while S3-S5 focus on motivation *after* playing the game.

ID	Statement
S1	It was important for me to do well in Escapade
S2	I did not try especially hard to do well in Escapade
S3	Playing Escapade can be of some value to me
S4	Playing Escapade made me less motivated in the course
S5	While I played, I wanted to learn more about some of the situations in the pictures

Table 27.1: Statements regarding motivations

27.2.2 Statements Related to Collaboration and Perceived Learning

The three statements in Table 27.2, regard the degree to which Escapade can enable collaboration in a way that promotes learning, i.e. RQ3.

S6 and S7 focus on the cooperative aspect of the game. As described in Chapter 26, the two groups we tested the game on had two different ways of collaborating. The following statement, S8, probes *perceived* learning, as there is no reliable way of tracking the actual learning effect throughout a single experiment.

ID	Statement
S6	I felt it was easy to cooperate with my team
S7	I felt that cooperation made the game harder
S8	I felt that I learned something from playing Escapade

Table 27.2: Statements regarding collaboration and perceived learning

27.2.3 Statements Related to Engagement

Table 27.3 displays four statements regarding engagement that participants answered. The primary focus of these statements was to examine how engagement was affected by the game's collaborative elements, as in RQ4. S9-S12 are related to how players perceive their focus or concentration level, which is linked to engagement.

ID	Statement
S9	I felt that I was focused while playing
S10	I felt that I had to concentrate to do well in the game
S11	I thought it was boring to play Escapade
S12	I felt an increase of my pulse while playing

Table 27.3: Statements regarding engagement

27.2.4 Statements Related to Enjoyment

The last statements, shown in Table 27.4, regard a player's enjoyment. These statements are intended to help discuss how player enjoyment is affected by the game's approach to collaboration, i.e. RQ5. S13 and S14 are direct statements of perceived enjoyment for a player.

ID	Statement
S13	Playing Escapade was fun
S14	I wish the game were a part of the history course at school

Table 27.4: Statements regarding enjoyment

27.2.5 Statement Related to the Time Factor

Table 27.5 shows *the last statement* in the questionnaire. This statement does not directly relate to any research question but is aimed to analyse whether the time element of the game affects motivation, collaboration, learning, engagement, or enjoyment.

ID	Statement
S15	Generally, I thought there was too little time for each round

Table 27.5: Statement about the time each round

27.2.6 General Questions

The general questions of this questionnaire, which are not directly related to our research questions, are divided into three categories: *demographics*, *gaming experience and interest for history*, and *contextual questions*.

Demographics

The questions gathering data on participants are shown in Table 27.6, specifically their name, email, age, and gender. The purpose of Q1 and Q2 is to identify the correct person in the case of withdrawal from the experiment. We included Q3 and Q4 to map the demographics of the test population.

ID	Question	Format
Q1	What is your name?	Text
Q2	What is your email address	Text
Q3	What is your age?	Text
Q4	What is your gender?	Multiple choice

Table 27.6: Demographics questions

Gaming experience and interest in history

Table 27.7 shows questions used to investigate whether participants' experience with gaming and interest in history could correlate to the game. Q5 used a text response format to encourage participants to think about their answers rather than simply selecting an option in a multiple-choice format. Q6 and Q7 used a Likert scale from "Not interested" to "Very interested".

ID	Question	Format
Q5	About how many hours do you play video games on average in a week?	Text
Q6	What is your interest level for the history course at school?	Likert Scale
Q7	What is your interest level for history outside of school?	Likert Scale

Table 27.7: Gaming experience and interest in history questions

Contextual questions

Table 27.8 shows questions regarding the context of the experiment. Teams in Escapade come in sizes of three or four, and each player has a different role. Q8-Q10 aims to see if there are any correlations between these contextual factors and the rest of the data. These questions were originally placed last in the questionnaire after all statements.

ID	Question	Format
Q8	How many were you in your group?	Text
Q9	What role did you have on your team?	Multiple choice
Q10	How would you describe your contribution to your team?	Text
Q11	Is there any other feedback you would like to give to us?	Text

Table 27.8: Contextual questions

27.3 Observations

We used an overt, participant observation method during the experiment, as mentioned in Section 4.6. By observing the participants, we could note how they played and collaborated. We mainly had a passive role but could assist participants with questions or technical issues. Unforeseen technical issues or bugs could pose a risk to how participants perceive the concept and needlessly affect the results of our research goals. By having a physical presence, we could direct the focus away from technical issues in favour of a more gameplay-focused experience.

27.4 Summary

This chapter presented our data collection methods and data privacy concerns. The data collection methods for this thesis consisted of a questionnaire and overt participant observation. The resulting data has the primary goal of helping us answer the research questions. The next chapter will discuss the reliability and validity of our data collection methods.

Chapter 28

Reliability and Validity

This chapter will describe some of the factors that might affect the validity or reliability of the results obtained during the experiment phase of this project. Our analysis will be based on the guidelines outlined by Oates in *Researching Information Systems and Computing* [11].

28.1 Internal Validity

The choice to perform two variations of the experiment on two different groups as opposed to trying both variations on the same group came down to wanting to maximise the *internal validity* of the experiment. Oates describes internal validity as an indicator of whether experiment results can be attributed to manipulations purposefully made by researchers [11]. An experiment with low internal validity produces results that might as well be the result of other factors. *Maturation* is the effect caused by participants changing between tests and is a threat to internal validity. Performing the two variations of the experiment on the same group of participants would undermine the change to the game rules, with a difference in results possibly being caused by the difference in experience with the game among the participants.

28.2 External Validity

The *external validity* of an experiment refers to the degree to which its results are generalisable. Oates writes that "the best way of demonstrating generalisability is to repeat the experiment many times in many situations" [11], but that experiments can also be designed so that they are likely to achieve high external validity. Oates describes three primary threats to external validity, non-representative participants, too few participants, and non-representative test cases. We believe that our experiment is relatively well-protected against all of these threats.

Non-representative Participants

The participants were selected due to their teacher's willingness to participate in the project, not their own enthusiasm (although participation was still voluntary). According to Oates, people who volunteer as participants "often have certain characteristics that differentiate them from the general population", and this issue is avoided by going through the students' teacher.

The number of students absent in the two classes was relatively high due to two reasons. On the day that the jigsaw group was tested, their teacher informed us that several students were absent due to a recruitment session organised by the military. In Norway, these are mandatory and follow an initial screening. Suppose the type of student who is most likely to pass said screening possesses certain traits that would affect their gameplay experience with Escapade. In that case, the recruitment might have caused differences between the jigsaw group and the non-jigsaw group. However, we believe this is fairly unlikely, as a wide variety of people are called in for the military's recruitment sessions.

The other reason for the high absence was the traditional Norwegian "russefeiring" [103], which is partaken in by 3rd-year upper secondary school students, who comprised both classes we experimented on. Skipping school is quite common during this period. The students who showed up to class might have possessed different traits that affected their experience with Escapade. Mitigating these factors would ideally be accomplished by running the experiment on more groups at another time of year, but this was not possible due to the scope and timeline of this project.

Too Few Participants

While it would be beneficial to have more participants, 36 is more than Oates's rule of thumb postulates is necessary for a small scale research project. Therefore, the number of participants is likely not a significant threat to the experiment's external validity.

Non-representative Test Cases

Finally, there is the issue of non-representative test cases. Experimenting in a history class is likely as good of a situation as possible for our experiment. However, the participants did know they were participating in a research project. This knowledge might have made them more likely to pay attention and try their best due to fear of disappointing us as researchers or their teachers. The students may have been more likely to "mess around" if this was a regular class activity. This effect is known as the *Hawthorne Effect* [104] and was likely present during our experiment because we did our observation overtly.

28.3 Summary

This chapter has outlined our evaluation of the reliability and validity of our experiment. Specifically, it has described some of the threats to the experiment's internal and external validity

using guidelines from Oates's *Researching Information Systems and Computing* [11]. We believe that the experiment generally shows good validity but has identified multiple areas of potential improvements, such as using more covert observations, observing more classes at a different time of year, and having a higher number of participants. We will consider the possible effect of the weaknesses described in this chapter as we advance in this thesis.

Part V

Results

This part describes the result of the project's experiment. We will portray the test population of the experiment and present results from the questionnaire. Furthermore, we will show the impact of various measurable factors, including the jigsaw method, interest in gaming and history, group size, and roles.

Chapter 29

Test Population

This chapter will summarise the participants' gender, age, interest in history as a subject both inside and outside of school, and time spent on gaming. 36 students participated in the experiment, with 16 from the first class (jigsaw class) and 20 from the second (non-jigsaw class).

29.1 Age and Gender Distribution

Figure 29.1 and Figure 29.2 show the age and gender distribution of all participants. The gender distribution inside each class was also reasonably equal. The jigsaw class had 8 male and 8 female participants, and the non-jigsaw class had 11 male and 9 female participants. The participants were all in the same grade of upper secondary school, so they were all either 18 or 19 years old. The age distribution saw the jigsaw class having a slightly higher average age. The jigsaw class had 10 18-year-olds and 6 19-year-olds, and the non-jigsaw class had 15 18-year-olds and 5 19-year-olds.

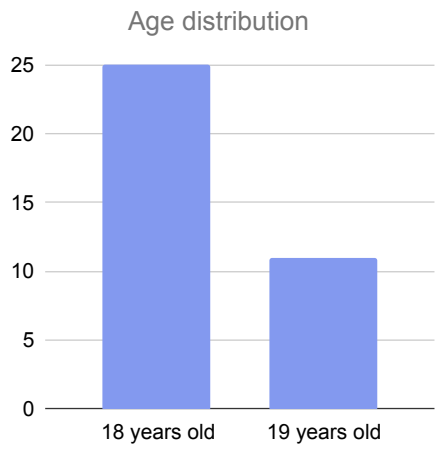


Figure 29.1: Age distribution among participants

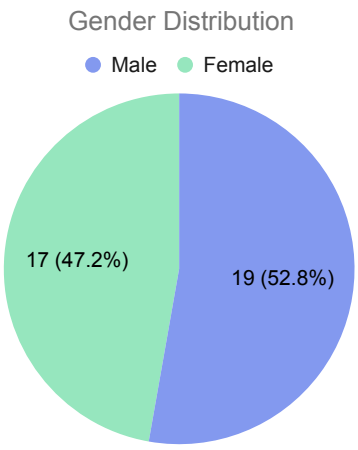


Figure 29.2: Gender distribution among participants

29.2 History Interest

Participants were asked about their interest in history as a subject in school and as a general theme outside of school. We reassured participants that their answers would not be shared

with their teacher. Figure 29.3 shows participants' interest in history as a school subject while Figure 29.4 shows participants' general interest in history. Both figures are categorised by jigsaw and non-jigsaw classes.

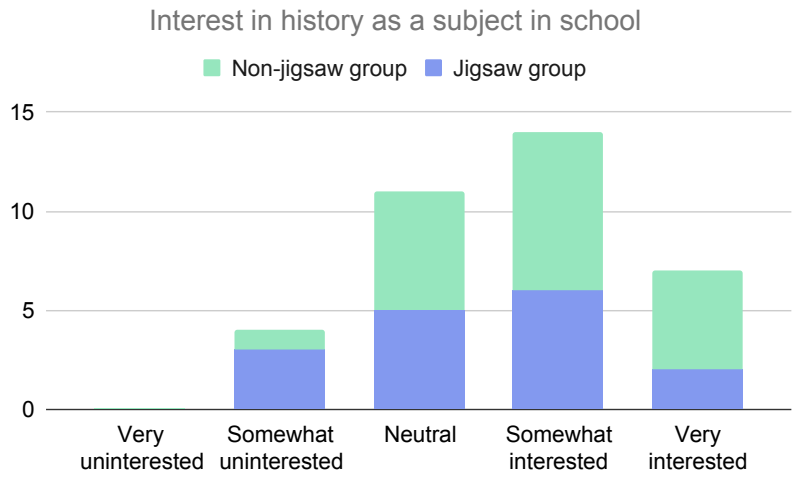


Figure 29.3: Participants' interest in history as a subject in school

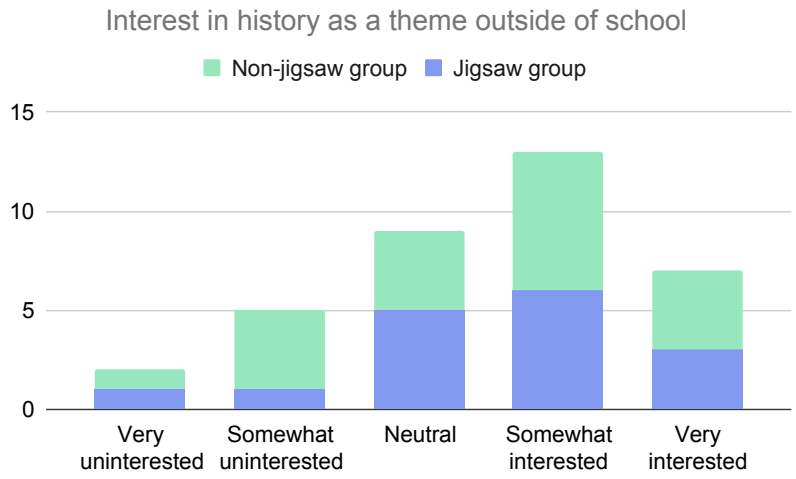


Figure 29.4: Participants' interest in history in general, outside of school

We can directly compare the average answers to both questions across both groups to conclude a few things. The following data assumes a scale between 1 (very uninterested) and 5 (very interested). The jigsaw class was more interested in history in general (3.56) than the history subject in school (3.44), albeit only very slightly. This result was the opposite of what the non-jigsaw class reported. Their answers showed they were more interested in the history subject (3.85) than the jigsaw class but less interested in history in general (3.45).

29.3 Time Spent Gaming

We also wanted to gauge whether participants' interest in gaming affected their experience with Escapade and thus asked for an estimate of how much time they spend on gaming per week. Figure 29.5 shows the result of this question, categorised by jigsaw and non-jigsaw class. Participants were asked to input a number of hours, but the data has been organised into six categories for readability.

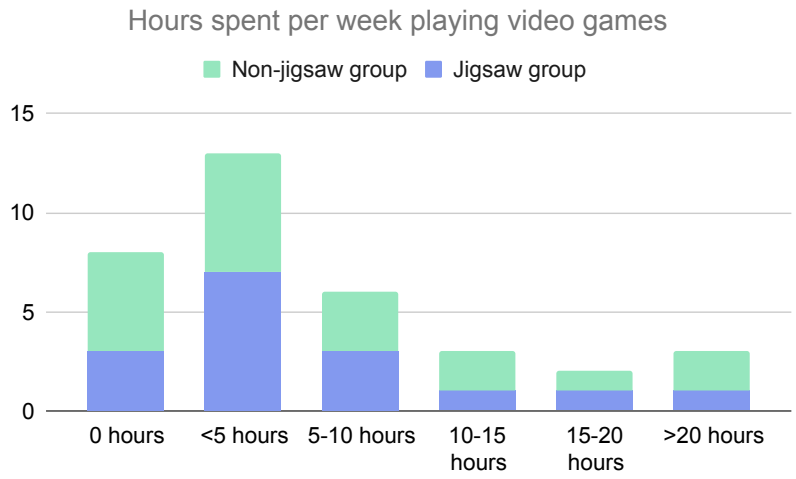


Figure 29.5: Hours spent per week playing video games among participants

The average number of hours played per week per participant in the non-jigsaw class (9.93) is almost twice as high as in the jigsaw class (5.38), but this is primarily caused by very high answers from a few participants. When comparing median responses, the non-jigsaw class (2.5) ends up under the jigsaw class (3). This result, in conjunction with the very similar distribution shown in Figure 29.5 indicates that an average participant in each group spends roughly the same number of hours playing video games.

29.4 Summary

This chapter has outlined the basic demographics of the test population and presented the history and gaming interests reported by participants. The two groups of participants (jigsaw and non-jigsaw) showed fairly similar age and gender distributions and a relatively equal interest in history and gaming.

Chapter 30

Data Collection Results

This chapter will present results from the questionnaire and the observations. Statements will be categorised similarly to Chapter 27. Each statement in a table is presented with an ID, group, number of participants, and a three-point Likert Scale. The test population is divided into two groups. In the *jigsaw class* participants were told that they could not look at each other's screens, while participants in the *non-jigsaw class* were encouraged to look at each other's screens. Both results are joined in the *combined* category. The three-point Likert Scale is comprised of the original five-point scale in the questionnaires for better readability.

30.1 Results on Motivation

As seen in Table 30.1, the responses for motivation-related statements were largely positive. 75% of the students agreed that it was important to do well playing Escapade (S1). Similarly, 75% disagreed when asked if they did not try hard in Escapade (S2). 72% thought the game could be of some value (S3), and 92% did not believe the game decreased their motivation in the history course. The answers for S5 were more neutral, with 56% agreeing and 31% being neutral to wanting to learn more about some of the situations in the pictures.

ID	Statement	Group	*n*	D	N	A
S1	It was important for me to do well in Escapade	Jigsaw class	16	0%	13%	88%
		Non-jigsaw class	20	5%	30%	65%
		Combined	**36**	**3%**	**22%**	**75%**
S2	I did not try especially hard to do well in Escapade	Jigsaw class	16	69%	31%	0%
		Non-jigsaw class	20	80%	10%	10%
		Combined	**36**	**75%**	**19%**	**6%**
S3	Playing Escapade can be of some value to me	Jigsaw class	16	0%	13%	88%
		Non-jigsaw class	20	25%	15%	60%
		Combined	**36**	**14%**	**14%**	**72%**
S4	Playing Escapade made me less motivated in the course	Jigsaw class	16	94%	0%	6%
		Non-jigsaw class	20	90%	5%	5%
		Combined	36	**92%**	**3%**	**6%**
S5	While I played, I wanted to learn more about some of the situations in the pictures	Jigsaw class	16	19%	25%	56%
		Non-jigsaw class	20	10%	35%	55%
		Combined	**36**	**14%**	**31%**	**56%**

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

Table 30.1: Results on statements regarding motivations

30.2 Results on Collaboration and Perceived Learning

Table 30.2 presents answers for collaboration- and perceived learning-related statements. 83% of the students felt that it was easy to cooperate with their team (S6). S7 shows that students' opinions are more split when asked if the cooperative element made the game harder, with 56% agreeing, 31% neutral, and 14% agreeing. Participants generally felt that they learned something, with 83% agreeing (S8).

ID	Statement	Group	*n*	D	N	A
S6	I felt it was easy to cooperate with my team	Jigsaw class	16	0%	25%	75%
		Non-jigsaw class	20	5%	5%	90%
		Combined	**36**	**3%**	**14%**	**83%**
S7	I felt that cooperation made the game harder	Jigsaw class	16	56%	31%	13%
		Non-jigsaw class	20	55%	30%	15%
		Combined	**36**	**56%**	**31%**	**14%**
S8	I felt that I learned something from playing Escapade	Jigsaw class	16	0%	13%	88%
		Non-jigsaw class	20	10%	10%	80%
		Combined	**36**	**6%**	**11%**	**83%**

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

Table 30.2: Results on statements regarding collaboration and perceived learning

30.3 Results on Engagement

Engagement-related answers are shown in Table 30.3. 83% of the students felt focused during gameplay (S9), and 75% thought that they had to concentrate on doing well in the game (S10). 94% of the students disagreed when asked if they thought Escapade was boring to play; in fact, none of the students agreed with this statement (S11). The last question in this category probed whether they felt increased pulse while playing. The answers varied, with 44% disagreeing, 22% being neutral, and 33% agreeing (S12).

ID	Statement	Group	*n*	D	N	A
S9	I felt that I was focused while playing	Jigsaw class	16	0%	19%	81%
		Non-jigsaw class	20	5%	10%	85%
		Combined	**36**	**3%**	**14%**	**83%**
S10	I felt that I had to concentrate to do well in the game	Jigsaw class	16	0%	19%	81%
		Non-jigsaw class	20	0%	30%	70%
		Combined	**36**	**0%**	**25%**	**75%**
S11	I thought it was boring to play Escapade	Jigsaw class	16	100%	0%	0%
		Non-jigsaw class	20	90%	10%	0%
		Combined	**36**	**94%**	**6%**	**0%**
S12	I felt an increase of my pulse while playing	Jigsaw class	16	50%	19%	31%
		Non-jigsaw class	20	40%	25%	35%
		Combined	**36**	**44%**	**22%**	**33%**

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

Table 30.3: Results on statements regarding engagement

30.4 Results on Enjoyment

Enjoyment-related answers, seen in Table 30.4, were predominantly positive. 81% of the students thought the game was fun, with 0% disagreeing (S13). Additionally, 83% wish the game was a part of the history course at school, with only 3% disagreeing (S14).

ID	Statement	Group	*n*	D	N	A
S13	Playing Escapade was fun	Jigsaw class	16	0%	19%	81%
		Non-jigsaw class	20	0%	20%	80%
		Combined	**36**	**0%**	**19%**	**81%**
S14	I wish the game was a part of the history course at school	Jigsaw class	16	6%	0%	94%
		Non-jigsaw class	20	0%	25%	75%
		Combined	**36**	**3%**	**14%**	**83%**

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

Table 30.4: Results on statements regarding enjoyment

30.5 Results on the Time Factor

The last category is affiliated with how much time they had each round and shown in Table 30.5. 78% of students disagreed that they had too little time each round (S15).

ID	Statement	Group	*n*	D	N	A
S15	Generally, I thought there was too little time each round	Jigsaw class	16	75%	25%	0%
		Non-jigsaw class	20	80%	10%	10%
		Combined	**36**	**78%**	**17%**	**6%**

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

Table 30.5: Results on the statement regarding the time factor

30.6 Results from Open-ended Questions

This section highlights feedback from participants on the questions *How would you describe your contribution to your team?* (Q10) and *Is there any other feedback you would like to give to us?* (Q11). It is worth noting that Q11 was a voluntary open-ended question, meaning not all participants responded to it.

Responses to Q10 regarding participants' contributions were mostly related to their roles. Explorers responded with mainly two things: they worked as a sort of "leader" for the team by

providing a direction for the two experts' research, and they analysed the image closely, trying to pick out details like flags that could help. Examples of responses from the explorer were:

"I provided an overview, [I] told them what we were looking for" and *"[I] had to describe the image, the explorer's job was important to the rest of the team being able to complete what they needed to do. [I] focused mostly on details that helped the team, flags, for example."*

The responses to Q10 from participants with the geography expert role primarily mention identifying flags as their most important task. Many geography expert responses also note the usefulness of their role, with the distribution of these responses being slightly different between the jigsaw and the non-jigsaw groups. Four out of six geography experts in the jigsaw group expressed that their role was essential to the team effort, while only two of seven did the same in the non-jigsaw group. Conversely, only one geography expert in the jigsaw group mentioned that they felt like their role was less important than others. At the same time, this was indicated by three people in the non-jigsaw group (two of which said so explicitly, while one pointed out that they did not concentrate during the game). Example responses from the non-jigsaw group were:

"As I was the expert in geography and flags, I felt that what I did was not especially important, as it was a small role with not much to do" and *"My contribution during the game was clarifying which location the event happened in. I think my role was overshadowed because the answers to the multiple-choice questions were too descriptive regarding where the location was. Example: This is an image of Vietnamese forces in Saigon."*

Responses to Q10 from participants with the history expert role were relatively uniform, mainly describing their work of filtering information in their data banks based on what the explorer in their team asked them to investigate. Multiple responses mention the need to focus and that the role was relatively challenging, indicating that history experts generally felt appropriately challenged and important to the team effort.

Responses to Q11 were largely positive. 17 participants responded by saying the game was good or enjoyable, with some saying they wished it was part of the history course. There was also quite a bit of constructive feedback. Participants mentioned an improved historical map for the history expert, tuning the difficulty (both up and down), decreased time per round, and background music as possible improvements. One person in the non-jigsaw group also pointed out that the geography expert role could be improved by making it have a higher workload.

30.7 Observational Results

Observations during the experiment confirmed some of the questionnaire results. Players were generally talkative and focused during rounds. One observation we made was that the jigsaw class seemed to talk among each other more compared to the non-jigsaw class. Additionally, since the classrooms had limited space, participants could also hear each other's discussions. This restriction led to one group realising they were underperforming, which affected their motivation. There were also upsides to the lack of space between teams. Participants seemed to be more engaged due to competitiveness stemming from talking with other teams in-between rounds.

There were some technical issues during the experiment that we detected. Some participants had a bug where game data did not update from the "Tutorial" to "The Cold War" game theme. A quick refresh fixed these issues. Another issue that appeared was related to the timer countdown. One player had zero seconds left for the whole duration of the game. A few other players had an overflow of the time bar, which led to them seeing that they had more than the given time of the round left. However, as not all participants in a team had this issue, it was mainly solved by asking about the remaining time from the other team members.

Escapade is played in real-time, and teams proceed to the next round when they are finished. As a consequence, teams will finish a game at different times. We observed that team that ended quickly had to wait for the others. This waiting time may have impacted players' enjoyment when having nothing else to do. Additionally, waiting could affect the other teams' collaboration as they may have felt more stress thinking they should be quicker.

30.8 Summary

This chapter summarises the results from the questionnaire and the observations. Statements were presented in three groups: jigsaw class, non-jigsaw class, and both combined, each with a corresponding three-point Likert Scale. Results from open-ended questions and observations were also presented. The next chapter will dive deeper into all results by calculating statistical significance between groups and the impact of factors from our data collection methods.

Chapter 31

Impact of Measurable Factors on Results

To gain further insight into the data collected, we applied the Mann-Whitney U test [17] to each statement, with the test population split into two groups in various ways. This division is utilised to evaluate whether there are significant differences in the answers of said two groups by returning a p-value, p, which denotes the likelihood that the observed differences in answers are due to chance. Results are considered statistically significant if $p \leq 0.05$.

For each of the following sections, we have split the participants into two groups based on different criteria and performed the Mann-Whitney U test for all statements in the questionnaire. In each section, only the questions which show statistically significant differences ($p \leq 0.05$) or which may indicate considerable differences ($p \leq 0.10$) are presented to limit the length of this chapter. A complete overview of all Mann-Whitney U test results and questionnaire results grouped by the criteria in this chapter are included in Appendix F.

This chapter will largely present results without discussing their implications or causes, which we will cover in Part VI of this thesis.

31.1 Impact of the Jigsaw Method

The three statements in Table 31.1 showed significant or borderline significant differences when we compared the jigsaw and non-jigsaw classes. The jigsaw class was more likely to feel that playing Escapade was of value to them (S3) ($p = 0.0336$) and were also more likely to wish the game was part of the history course in school (S14) ($p = 0.0351$). Furthermore, our results indicate that using the jigsaw method might affect whether students felt that they learned something from playing the game (S8) ($p = 0.0537$). Interestingly, the jigsaw method was the only factor close to showing a significant impact on this statement, with the second closest factor being group size ($p = 0.1814$).

ID	Statement	Group	*n*	D	N	A	p
S3	Playing Escapade can be of some value to me	Jigsaw class	16	0%	13%	88%	**0.0336**
		Non-jigsaw class	20	25%	15%	60%	
S8	I felt that I learned something from playing Escapade	Jigsaw class	16	0%	13%	88%	0.0537
		Non-jigsaw class	20	10%	10%	80%	
S14	I wish the game was a part of the history course at school	Jigsaw class	16	6%	0%	94%	**0.0351**
		Non-jigsaw class	20	0%	25%	75%	

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

p: Results from Mann-Whitney U test

Table 31.1: Impact of the jigsaw method, statements where $p \leq 0.10$

31.2 Impact of Participants' Gaming Interest

As can be seen in Table 31.2 and Table 31.3, participants' level of gaming interest was rather impactful in how they experienced the game. Two questions and nine statements showed a significant or close-to-significant difference between groups with low and high gaming interest. *Low gaming interest* was defined by a participant spending two hours or less on playing video games each week, with increased interest constituting participants who spent more than two hours weekly.

ID	Question	Group	*n*	L	N	H	p
Q6	What is your interest level for the history course at school?	Low interest	17	6%	47%	47%	0.0516
		High interest	19	16%	16%	68%	
Q7	What is your interest level for history outside of school?	Low interest	17	29%	35%	35%	**0.0239**
		High interest	19	11%	16%	74%	

n: Number of participants **L**: Low **N**: Neutral **H**: High

p: Results from Mann-Whitney U test

Table 31.2: Impact of participants' gaming interest, questions where $p \leq 0.10$

Firstly, it is evident that a participant with a high interest in video games is also more likely to be interested in history, both as a school subject (Q6) (though borderline, $p = 0.0516$) and in general (Q7) ($p = 0.0239$). This fact makes it likely that statements significantly impacted by one of these three interests will also be affected by one or both of the other interests. To further examine the personal impact of participants' interests in gaming, history as a subject, and history in general, correlation values (r_s) between these interests and all statements have been calculated using Spearman's rank correlation coefficient [18]. The result of all said calculations can be found in Appendix F.

ID	Statement	Group	*n*	D	N	A	p
S1	It was important for me to do well in Escapade	Low interest	17	6%	29%	65%	**0.0091**
		High interest	19	0%	16%	84%	
S2	I did not try especially hard to do well in Escapade	Low interest	17	71%	18%	12%	0.0823
		High interest	19	79%	21%	0%	
S3	Playing Escapade can be of some value to me	Low interest	17	18%	29%	53%	**0.0485**
		High interest	19	11%	0%	89%	
S5	While I played, I wanted to learn more about some of the situations in the pictures	Low interest	17	18%	41%	41%	**0.0436**
		High interest	19	11%	21%	68%	
S6	I felt it was easy to cooperate with my team	Low interest	17	6%	18%	76%	**0.0188**
		High interest	19	0%	11%	89%	
S7	I felt that cooperation made the game harder	Low interest	17	47%	35%	18%	0.0655
		High interest	19	63%	26%	11%	
S12	I felt an increase of my pulse while playing	Low interest	17	59%	18%	24%	0.0582
		High interest	19	32%	26%	42%	
S13	Playing Escapade was fun	Low interest	17	0%	29%	71%	0.0618
		High interest	19	0%	11%	89%	
S15	Generally, I thought there was too little time each round	Low interest	17	82%	12%	6%	0.0655
		High interest	19	74%	21%	5%	

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

p: Results from Mann-Whitney U test

Table 31.3: Impact of participants' gaming interest, statements where $p \leq 0.10$

Among the most apparent differences between participants with low and high gaming interest was the importance of performing well in the game (S1) ($p = 0.0091$). Those with high gaming interest are much more likely to agree that it was important for them to do well; this is echoed by signs of significance in S2 ($p = 0.0823$). Along with being more competitive, participants interested in gaming also reported that they found it significantly easier to cooperate with their team in S6 ($p = 0.0188$). They also indicated that they were less likely to find that the game's collaboration elements made it more difficult (S7) ($p = 0.0655$, borderline).

Another difference indicated by these results is an apparent higher level of enjoyment and engagement among participants with a high interest in gaming, seen through S12 and S13 ($p = 0.0582$ and $p = 0.0618$, respectively, borderline). Those with high interest in gaming were also much more likely to respond that they felt Escapade could be of value to them (S3), with 89% agreeing in contrast to 53% among those with low gaming interest ($p = 0.0485$). S5, which regards motivation, was also more likely to receive a positive answer from a participant with a high interest in gaming ($p = 0.0436$). Its correlation to gaming interest ($r_s = 0.2222$) is lower than its cor-

relation to interest for history as a subject ($r_s = 0.4954$) and as a general theme ($r_s = 0.2734$). Therefore, it is certainly possible that the observed difference is partly due to the connection between gaming and historical interests among participants.

Finally, gaming interest was the only significant factor in whether participants felt they had too little time per round (S15) ($p = 0.0655$). Those with high gaming interest were more likely to think so.

31.3 Impact of Participants' Interest in History as a School Course

Table 31.4 and Table 31.5 show the results that produced a significant difference when comparing participants with high and low interest in the history course in school. *Low interest* comprises participants who answered 1-3 (very low-neutral) when asked about their interest in the history subject. In contrast, those in the *high interest* group responded with 4 or 5 (some interest or significant interest).

ID	Question	Group	*n*	L	N	H	p
Q7	What is your interest level for history outside of school?	Low interest	15	33%	33%	33%	**0.0089**
		High interest	21	10%	19%	71%	

n: Number of participants **L**: Low **N**: Neutral **H**: High

p: Results from Mann-Whitney U test

Table 31.4: Impact of participants' interest in history as a school subject, question where $p \leq 0.10$

Unsurprisingly, there is a significant link (Q7) ($p = 0.0089$) between students interested in the history course and those interested in history in general. 71% of participants were interested in the history course stating they also enjoy history in general, while only 33% of those with little interest in it indicated so.

ID	Statement	Group	*n*	D	N	A	p
S1	It was important for me to do well in Escapade	Low interest	15	7%	20%	73%	0.0594
		High interest	21	0%	24%	76%	
S2	I did not try especially hard to do well in Escapade	Low interest	15	60%	27%	13%	**0.0037**
		High interest	21	86%	14%	0%	
S5	While I played, I wanted to learn more about some of the situations in the pictures	Low interest	15	20%	40%	40%	**0.0122**
		High interest	21	10%	24%	67%	
S7	I felt that cooperation made the game harder	Low interest	15	40%	33%	27%	**0.0119**
		High interest	21	67%	29%	5%	
S9	I felt that I was focused while playing	Low interest	15	7%	20%	73%	**0.0222**
		High interest	21	0%	10%	90%	
S11	I thought it was boring to play Escapade	Low interest	15	87%	13%	0%	0.0505
		High interest	21	100%	0%	0%	
S12	I felt an increase of my pulse while playing	Low interest	15	67%	13%	20%	**0.0401**
		High interest	21	29%	29%	43%	
S13	Playing Escapade was fun	Low interest	15	0%	33%	67%	**0.0192**
		High interest	21	0%	10%	90%	

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

p: Results from Mann-Whitney U test

Table 31.5: Impact of participants' interest in history as a school subject, statements where $p \leq 0.10$

Those with high interest for the history course were also more engaged in the game (S1, S2, S9, S12) ($p = 0.0594$ borderline, $p = 0.0037$, $p = 0.0222$, $p = 0.0401$) and were more likely to feel that the game's collaborative aspect did not make it harder (S7) ($p = 0.0119$). This finding mirrors the results of participants with a high interest in video games. An interesting distinction here is that, unlike in the gaming-interested group, there were no significant differences in how easy cooperation was perceived to be (S6) ($p = 0.1210$), only in the overall effect cooperation had on the game experience (S7).

A participant's interest in the history course was also by far the most crucial factor in how much they wanted to learn about the situation they encountered in the game (S5) ($p = 0.0122$). The statement's correlation with history course interest was much higher than with gaming interest or general history interest ($r_s = 0.4954$ compared to $r_s = 0.2222$ and $r_s = 0.2734$, respectively). Finally, those with high interest in the history course enjoyed the game more (S13) ($p = 0.0192$), with all of the 21 participants in the group reporting that they disagreed with Escapade being boring (S11) ($p = 0.0505$, borderline).

31.4 Impact of Participants' Interest in History as a General Theme

Table 31.6 and Table 31.7 show how participants' general interest in history affected their responses to the various statements. Like in the previous section, *low interest* comprises participants who answered 1-3 (very low-neutral), while those in the *high interest* group responded with 4 or 5 (some interest or significant interest).

ID	Question	Group	*n*	L	N	H	p
Q6	What is your interest level for the history course at school?	Low interest	16	25%	38%	38%	**0.0136**
		High interest	20	0%	25%	75%	

n: Number of participants **L**: Low **N**: Neutral **H**: High

p: Results from Mann-Whitney U test

Table 31.6: Impact of participants' interest in history as a school subject, question where $p \leq 0.10$

ID	Statement	Group	*n*	D	N	A	p
S2	I did not try especially hard to do well in Escapade	Low interest	16	63%	25%	13%	**0.0262**
		High interest	20	85%	15%	0%	
S5	While I played, I wanted to learn more about some of the situations in the pictures	Low interest	16	25%	25%	50%	0.0838
		High interest	20	5%	35%	60%	
S6	I felt it was easy to cooperate with my team	Low interest	16	6%	6%	88%	0.0934
		High interest	20	0%	20%	80%	
S9	I felt that I was focused while playing	Low interest	16	6%	25%	69%	**0.0071**
		High interest	20	0%	5%	95%	
S11	I thought it was boring to play Escapade	Low interest	16	88%	13%	0%	0.0778
		High interest	20	100%	0%	0%	
S12	I felt an increase of my pulse while playing	Low interest	16	69%	6%	25%	**0.0446**
		High interest	20	25%	35%	40%	
S13	Playing Escapade was fun	Low interest	16	0%	31%	69%	**0.0359**
		High interest	20	0%	10%	90%	
S14	I wish the game was a part of the history course at school	Low interest	16	6%	19%	75%	**0.0268**
		High interest	20	0%	10%	90%	

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

p: Results from Mann-Whitney U test

Table 31.7: Impact of participants' interest in history as a school subject, statements where $p \leq 0.10$

As expected, the results here are similar to those examining interest for the history course, although with a few notable differences. Firstly, participants' interest in history as a theme did not significantly affect their need to perform well in Escapade (S1) ($p = 0.1357$), which is the opposite of the case with interest in the history course. Furthermore, the impact on S6 and S7 is lower, with S6 barely indicating significance ($p = 0.0934$) while S7 did not ($p = 0.1587$). Finally, in general, those interested in history were much more likely to wish it was part of the history course at school (S14) ($p = 0.0268$), with this factor being the statement's only significant one besides the use of the jigsaw method.

31.5 Impact of Group Size

The default number of players per team in Escapade is three, but since not all numbers are divisible by three, some four groups had to be formed during the experiment. Table 31.8 shows the questions in which group size was a significant or close-to-significant factor. As seen in the table, the only questions where a significant difference can be seen are Q6 and Q7, regarding participants' interest in history. This result means that a disproportionate number of participants interested in history ended up in 4-person groups. What is arguably more interesting is the lack of a table with statements that showed significant differences. Group size did *not* make a significant difference in any of the statements regarding the game, a takeaway that we will discuss further in Part VI.

ID	Question	Group	*n*	L	N	H	p
Q6	What is your interest level for the history course at school?	3-person group	23	13%	39%	48%	**0.0262**
		4-person group	13	8%	15%	77%	
Q7	What is your interest level for history outside of school?	3-person group	23	30%	17%	52%	0.0778
		4-person group	13	0%	38%	62%	

n: Number of participants **L**: Low **N**: Neutral **H**: High

p: Results from Mann-Whitney U test

Table 31.8: Impact of group size, statements where $p \leq 0.10$

31.6 Impact of Role

Escapade's three roles make for relatively different gameplay experiences with varied tasks. This section will compare each role to the other two to examine how the different roles impacted gameplay.

The Explorer Role

Table 31.9 displays responses given by players who had the explorer role and compares these with all other responses (the two expert roles, in this case). An indication can be seen that players with the explorer role might, to a more significant degree than others, feel like they need to concentrate on doing well, with 85% agreeing with S10 instead of just 70% among other roles ($p = 0.0838$). Explorers were also significantly more likely to have felt an increase in pulse (S12) ($p = 0.0314$), adding to the indication from S10 that the role requires focus and engages players. It is also indicated that explorers are more likely to find the game boring (S11) ($p = 0.0606$) since they submitted the only two neutral responses to this statement.

ID	Statement	Group	*n*	D	N	A	p
S10	I felt that I had to concentrate to do well in the game	Explorer role	13	0%	15%	85%	0.0838
		Other roles	23	0%	30%	70%	
S11	I thought it was boring to play Escapade	Explorer role	13	85%	15%	0%	0.0606
		Other roles	23	100%	0%	0%	
S12	I felt an increase of my pulse while playing	Explorer role	13	23%	23%	54%	**0.0314**
		Other roles	23	57%	22%	22%	

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

p: Results from Mann-Whitney U test

Table 31.9: Impact of having the explorer role while playing, statements where $p \leq 0.10$

The Geography Expert Role

Shown in Table 31.10 are the statements with significant differences in response when examining those coming from players who had the geography expert role. Standing starkly in opposition to the responses from explorer players, geography experts reported a significantly lower-than-average need to concentrate during the game in S10 ($p = 0.0051$). Only 54% agreed with the statement, compared to 87% among other roles. Additionally, only 8% reported an increase in pulse during the game, compared to 48% among different roles ($p = 0.0233$).

ID	Statement	Group	*n*	D	N	A	p
S10	I felt that I had to concentrate to do well in the game	Geography expert role	13	0%	46%	54%	**0.0051**
		Other roles	23	0%	13%	87%	
S12	I felt an increase of my pulse while playing	Geography expert role	13	69%	23%	8%	**0.0233**
		Other roles	23	30%	22%	48%	

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

p: Results from Mann-Whitney U test

Table 31.10: Impact of having the geography expert role while playing, statements where $p \leq 0.10$

The History Expert Role

Table 31.11 and Table 31.12 show the significant differences in results when looking at the history expert role. Interestingly, history experts were significantly more interested in the history course, indicating that those who enjoy the course might be more likely to select this role (Q6) ($p = 0.0446$). The difference is severe, with the fraction of history experts who reported interest in the history course being effectively twice as high (90% versus 46%). When evaluating whether they did not try very hard to do well, every history expert disagreed, while only 65% of other roles did so (S2) ($p = 0.0418$).

ID	Question	Group	*n*	L	N	H	p
Q6	What is your interest level for the history course at school?	History expert role	10	0%	10%	90%	**0.0446**
		Other roles	26	15%	38%	46%	

n: Number of participants **L**: Low **N**: Neutral **H**: High

p: Results from Mann-Whitney U test

Table 31.11: Impact of having the history expert role while playing, question where $p \leq 0.10$

ID	Statement	Group	*n*	D	N	A	p
S2	I did not try especially hard to do well in Escapade	History expert role	10	100%	0%	0%	**0.0418**
		Other roles	26	65%	27%	8%	

n: Number of participants **D**: Disagree **N**: Neutral **A**: Agree

p: Results from Mann-Whitney U test

Table 31.12: Impact of having the history expert role while playing, statement where $p \leq 0.10$

31.7 Summary

Employing the Mann-Whitney U test [17] on our set of responses according to various criteria has exposed significant factors for many of the statements. These factors will help us analyse our data with much more nuance than if we were to only take the responses at face value. The data presented in this chapter will be used in Chapter 32, where we discuss the possible implications and causes of the participants' responses.

Part VI

Discussion & Conclusion

The final part of this Master's Thesis will discuss the project's result. Following this, we will conclude the thesis with our research questions and research goal. Finally, a project retrospective will be presented along with our recommendations for further work in the field.

Chapter 32

Discussion of Results

In this chapter, we will continue to delve into the results gathered from the experiment, which were presented in Part V. This chapter will discuss possible causes for the results observed and present some takeaways from the project. This discussion will be loosely based on the research goal and questions raised in Chapter 3, with a formal conclusion of these in the conclusion of the thesis (Chapter 33).

32.1 Discussing General Results

To begin with, we will discuss the results for all participants without comparing various sub-groups among them. Following this section, multiple factors and their impacts will be addressed, similarly to the chapters where results were presented (Chapter 30 and Chapter 31).

Motivation

Participants generally felt that *the game had a positive impact on their motivation in the history course*. Only three participants responded that the game made them less motivated (S4), and most people (75%) said it was important for them to do well in the game (S1). This impression was backed up by the questionnaire's open-ended questions and informal feedback received during the experiment. For example, multiple participants praised the game for being a method of learning that was different from those they were used to. Game-based learning has previously been used to successfully improve the motivation of upper secondary school students [5], and we were expecting to see this effect in our experiment. However, it is difficult to quantify how much of the effect on motivation is caused by specific elements of the game's design and how much comes down to students appreciating a break from standard lectures.

The statement probing whether participants became interested in learning more about situations from the game (S5) showed relatively positive results, with 56% responding that they did. This result indicates that playing Escapade *piqued participants' history interest*, not just improving their motivation in the school course. While we anticipated that participants would enjoy the game, we did not expect that such a high percentage of players would be motivated to learn more about the photographs they saw. We expected participants to treat the pictures more like

video game levels, which are often quickly mentally discarded upon reaching the next one. The reason behind this high percentage may be that participants experienced the cognitive curiosity described by Malone [27] (see Chapter 8). Seeing an image and situation they were unfamiliar with might have triggered a wish to complete their knowledge structures.

Collaboration and Perceived Learning

We believe that the game's collaborative and competitive elements were its biggest strengths. Combining a per-round time limit, intergroup collaboration, and intragroup competition made players start working towards their goals immediately. Between rounds, some participants asked their friends in other groups what score they had achieved and gloated if it was lower than their own. This type of competition seemed to motivate participants to perform as well as possible, wanting to beat their friends. While one could think that this sort of competition would be demotivating to less competitive or low-scoring groups, we only observed one example of this.

Most of the seemingly less competitive groups kept to themselves. They seemed to enjoy the collaboration aspect without worrying too much about their scores compared to everyone else, possibly because only the top three groups' scores were shared. This opinion is entirely based on observation since our questionnaire did not cover *how* competitive elements affected groups. To draw any conclusions regarding this, one would need more detailed data on the issue. The group that did become less motivated was a highly competitive group that had talked frequently with a neighbouring group about their scores. When it became clear they could no longer beat their neighbours, they disengaged somewhat and seemed to take the game less seriously.

It would be ideal to follow classes of students using the game in the history course over some time while comparing their academic progress to a control group. This methodology was not possible during this project due to our scope and timeline. Instead, the questionnaire asked if participants felt that they learned something (S8), to which 83% agreed.

A learning effect was also observed during the experiment. Participants remarked that they were unfamiliar with some of the conflicts introduced to them by the game. In some groups, players with previous knowledge of the historical event would introduce their teammates to it, likely providing a learning effect for all parties involved. Seeing this form of collaborative learning was exciting. We had hoped that players would end up discussing history while still being immersed in the game. This type of learning is central to social constructivism, which was described in Chapter 6. Players discussing history they were only somewhat familiar with while getting help from their classmates is an example of a learner receiving the necessary support to operate in

the zone of proximal development [19]. 83% of participants found it easy to cooperate with their team (S6), with only 14% saying the cooperation made the game harder (S7). *This result supports our impression that the game's collaboration came naturally to players.*

Engagement and Enjoyment

Results from the experiment related to *engagement and enjoyment* were also generally very positive. With a few exceptions, this was also backed up by our observations. Almost all participants seemed engrossed in the game, and there was frequent chatter in every group. An exception to this was that some of the geography experts in the non-jigsaw class seemed relatively disengaged at times, something we will discuss further in the following sections.

One of the elements that created the tension that forced players to engage with the game quickly was that each round had a time limit. We attempted to set a time limit that would stress players while still giving them enough time to discuss and research adequately. Since the learning effect of the game depends on players absorbing the material they read and discussed, we did not want to rush them to the point where they cut corners in this area.

While we believe the time limit played a positive part in players' engagement, most teams did not get especially close to spending all their time. 78% of players disagreed that the time limit was too low (S15), and multiple participants mentioned a shorter time limit as a potential improvement to the game. Decreasing the time limit could have a positive effect by necessitating more concentration from players and increasing the overall challenge. Concentration and challenge are two elements of GameFlow [29], and an improvement of these elements would likely result in a more enjoyable video game (GameFlow is described further in Chapter 9). 81% of participants stated that the game was fun, with the remaining 19% of responders being neutral to the statement (S13). The game being fun or good was also by far the most common response in the final open-ended question of the questionnaire, which asked for general feedback (Q11).

32.2 Discussing the Impact of the Jigsaw Method

This section will discuss the impact of the jigsaw method. The discussion will revolve around the data presented in Section 31.1.

Incorporating the jigsaw method as a part of its design is perhaps our game's most distinguishing feature as a collaborative educational game. While we expected participants to experience the game differently depending on whether they were in the jigsaw class, we were unsure if this would

materialise as a statistically significant difference in any statements. Previous research on the jigsaw method has observed significant impacts on motivation, engagement, and in most cases, learning [23, 24, 25]. Previous research, however, has primarily been focused on more traditional learning methods, not game-based learning. Two statements turned out to show significant differences. The first statement regarded whether participants thought the game could provide value to them (S3) ($p = 0.0336$). The second statement asked whether participants wished the game could be part of the history course in school (S14) (0.0351). The statement asking whether participants felt that they learned something (S8) ended up just above the limit of statistical significance ($p = 0.0537$), possibly indicating significance. We found that the three statements that showed significance (or an indication thereof) were particularly interesting. S3 and S14 only have *one* other significant factor impacting them, while jigsaw grouping is the *only* factor close to significance for S8.

Most of the statements in the questionnaire regarded a specific element of a participant's experience with the game, such as their motivation or enjoyment. S3 and S14, on the other hand, were the only questions assessing participants' thoughts about the game as a whole. Since the jigsaw class showed significantly more positive results in both statements, *this could indicate that the inclusion of the jigsaw method caused a considerably better overall experience with the game.* That this single game design element would have such a meaningful impact on the overall experience and takeaway of players took us by surprise.

Based on observations, we believe that the game saw more success in the jigsaw class partially because fewer players disengaged from the game. While not every role saw the same level of engagement, with the geography expert role seeing the lowest levels, we believe that using the jigsaw method somewhat mitigated this difference. The geography expert's info bank (containing flags and maps) was needed to arrive at the correct answers. An exception would be if the explorer were unusually well-versed in flag and geography knowledge, but we did not observe this. In the jigsaw class, the geography expert was "forced" to stay engaged to provide the information from their info bank. In the non-jigsaw class, explorers could effortlessly look at the geography expert's screen, possibly bypassing the geography expert and causing them to disengage from the game.

This finding could theoretically happen to players with the other roles as well, but we did not observe this. The history expert had a large amount of text to read through, so this was not easily accomplished by other players who also had to fulfil their roles. The explorer still needed to input the answers, meaning they too had to stay engaged to a certain degree. *If*

the jigsaw method did help players stay engaged with the game in the jigsaw class, this could cause a difference in both Escapade's perceived value to participants and their desire to have the game be part of the history course. This hypothesis is somewhat weakened because there were no statistically significant differences in responses to statements regarding the focus and concentration of participants during gameplay (such as S9 and S10).

Since the jigsaw method changes how players collaborate, we expected to see a difference in *I felt it was easy to cooperate with my team* (S6) or *I felt that cooperation made the game harder* (S7). Neither of the statements, however, provided any statistically significant differences, with respective p-values of $p = 0.1894$ and $p = 0.4286$.

I felt that I learned something from playing Escapade (S8) is the only statement directly examining the perceived learning effect of the game. As mentioned, no other factor than the jigsaw method comes close to statistical significance for the statement. While not technically statistically significant either, the low p-value indicated that the players in the jigsaw class were more likely to feel that they learned something from playing the game. This indication is not the same as saying that using the jigsaw method caused a positive difference in the learning effect. After all, perceived learning is not the same as learning, with one study finding no correlation between the two [105]. Students partaking in active learning (such as the students in our project) may underestimate how much they learn [106].

Furthermore, a previous study on the effect of the jigsaw method when using game-based learning did observe a better learning effect in the jigsaw group [26]. *Our results indicated that using the jigsaw method element of the game's design might positively affect feelings of learning.* However, a link to the actual learning effect is uncertain. Further experimentation is needed to conclude this topic.

32.3 Discussing the Impact of Gaming and History Interests

Three factors connected to a statistically significant degree were participants' gaming interest, interest in the history course, and interest in history in general. Someone who spends a lot of time playing video games is more likely to enjoy the history course ($p = 0.0516$, borderline) and be interested in history outside of school ($p = 0.0239$). Naturally, there is also a link between interest in history in and out of school ($p = 0.0089$). Unsurprisingly, this can lead to statements which show statistically significant differences in multiple of these factors. It can be hard to distinguish between the impact of each factor in these cases. Because of this, we also calculated

the correlation between each statement and these three factors using Spearman's rank correlation coefficient [18]. The correlation is only used to compare the impact of these three factors, with the Mann-Whitney U test (also used elsewhere in this thesis) still being used to draw conclusions and judge significance. Because of this, the p-value accompanying the correlation coefficients is not presented. The degree of similarity between the three factors discussed in this section is why they have been grouped for discussion.

When analysing the difference these three interests made to participant responses, one thing is immediately obvious; *players interested in gaming or history had a significantly more positive experience with the game than those who were not.* Those interested in history (both in the course and in general) were significantly more focused during the game ($p = 0.0222$ and $p = 0.0071$), and indicated that they found the game less boring ($p = 0.0505$ and 0.778, both borderline). In the following four statements, all three interests were significant (or close to significant) factors:

- *I did not try especially hard to do well in Escapade* (S2). Participants with a high interest in gaming or history were more likely to disagree with this statement, indicating that they tried harder to do well than those with low interest.
- *While I played, I wanted to learn more about some of the situations in the pictures* (S5). Here, all three interests resulted in more positive responses.
- *I felt an increase of my pulse while playing* (S12). Those with high levels of gaming or history interest were significantly more likely to have experienced elevated pulse, indicating a high level of engagement.
- *Playing Escapade was fun* (S13). Those with high interests in gaming or history were significantly more likely to agree.

This pattern repeats throughout the statements in which one or more of these three interests play a statistically significant role. Consequently, it is difficult to differentiate whether all three interests are equally important. It is also possible that one or two truly matter to the player experience, while the other(s) only indicate statistical significance due to their high degree of correlation with the truly significant interests. Ideally, we would have a significantly more extensive data set to further research this. With our current data, only 3 of the 19 participants with high gaming interest were categorised as having low interest in history both inside and outside of school.

Interest in gaming and history also impacted the statements assessing how participants exper-

ienced cooperation in the game. *Participants with high gaming interest were far more likely to agree that they found it easy to cooperate with their team (S6)* ($p = 0.0188$), showing that experience with video games might be advantageous when collaborating with their teammates. When analysing by history interest, the p-values were relatively low, though not significantly so, with $p = 0.1210$ for the history course and $p = 0.0934$ for history in general. When asked if they thought cooperation made the game harder (S7), interest in the history course proved the only statistically significant factor ($p = 0.0119$). Those with a high interest in gaming were, like those who enjoyed the history course, less likely to think the game was made harder by cooperation, though to a lower degree of significance ($p = 0.0655$).

There were only three statements (S3, S14, and S15) in which exactly one of the three interests showed a significant difference. As mentioned in the previous section, players being in the jigsaw class was one of two factors affecting whether they thought Escapade could be of value to them (S3). The other factor is their interest level in gaming ($p = 0.0485$). Participants with high gaming interest were more likely to agree that the game could provide them value. Those with high gaming interest indicated a more positive experience with the game, almost across the board. Participants were also asked if they wished the game could be part of the history course in school (S14). The jigsaw class gave this statement significantly more positive responses, but it was also affected by participants' interest in history in general ($p = 0.0268$).

Interestingly, participants' interest in the history course caused no significant differences. This finding could indicate that Escapade could inject some of the elements of history that students enjoy into the history course. It could also simply mean that those who already enjoy the history course (naturally) were happier with the current content of the course.

Finally, the questionnaire asked if participants thought they had too little time each round (S15). We found no statistically significant factors here, but gaming interest was close ($p = 0.0655$). Those with high gaming interests were more likely to agree that they had too little time. We found this relatively unexpected since previous statements indicated that high-gaming-interest participants had an easier time cooperating and were more focused. One possible explanation is that those who spend their time playing video games are more competitive and more likely to want to perfect their answers. This hypothesis is backed up by S1 (*"It was important for me to do well in Escapade"*), to which participants with high gaming interest were much more likely to agree ($p = 0.0091$).

Participants' interest in gaming, the history course, and history as a general theme were all very impactful factors in the gameplay experience, more so than we expected. *While results for*

low-interest groups in each of these categories were still good, it is clear that Escapade offers a significantly more positive experience to those already interested in gaming and/or history. Studies on whether previous gaming experience affects the effectiveness of game-based learning have arrived at different conclusions [5, 107]. We were therefore curious about our results, although we hoped that the game would see fairly universal effectiveness. Furthermore, evaluating which factors were most important in various statements was challenging due to how heavily interest in these three categories correlated among participants.

32.4 Discussing the Impact of Group Size and Roles

This final section will discuss the impact group size and in-game roles had on participants' responses. While the game was primarily designed with three-player groups in mind, the design facilitated four-player groups to ensure that every player in a class had a group. In the four-player groups, two players would share the role of the explorer, sitting beside each other and using the same computer. We were curious how this would affect players, for example, if it could cause one explorer to disengage while the other did all the work. During the experiment, we observed that in four-player groups, the two explorers would often discuss the task with each other and consult with their team. We believe that sharing a computer helped since they had to sit close to each other to see the screen. It is also possible that physically sharing the computer reminded them that they also needed to share the explorer's responsibility. Based on our observations, being four people in a group did not worsen the game experience.

These observations are backed up by the questionnaire data, in which *none of the statements showed any statistically significant differences between three- and four-player groups.* However, some significant differences were seen in the preliminary questions that mapped participants' interest in history. Participants in four-player groups were more likely to be interested in both the history course ($p = 0.0262$) and history in general ($p = 0.0778$, borderline). During the experiment, groups were formed by having participants group up with the people sitting close to them. Therefore, the difference in history interest is not immediately obvious, making it difficult to draw any interesting conclusions from this finding. The main takeaway from the group size analysis is, therefore, that *group size had no significant impact on how participants experienced the game.*

The Explorer Role

The explorer role seemed to engage players more than other roles based on responses to open-ended questions and the multiple-choice statements. Answers to the open-ended questions from explorers often mentioned that the role seemed very important. They also stressed the need to stay focused, be precise, and not feed their teammates erroneous information. The need to concentrate and a higher-than-average engagement level were also seen in explorers' answers to the questionnaire statements. When asked if participants felt the need to concentrate on doing well in the game (S10), results indicated that explorers were more likely to agree ($p = 0.0838$, borderline). A significant difference was also observed in the statement asking if participants noticed an increase in pulse while playing (S12) ($p = 0.0314$). Especially stark are the differences seen in S12; *54% of explorers agreed and 23% disagreed, while this was effectively reversed for other roles, with only 22% agreeing and 57% disagreeing.*

It should also be mentioned that when asked if the game was boring (S11), explorers agreed more often than others. Though not statistically significant, the p-value was very close ($p = 0.0606$). The responses to this statement were, on the whole, overwhelmingly towards disagreement. Only two participants gave neutral answers, and zero participants agreed. The two participants who responded neutrally both had the explorer role. We do not believe this is enough to conclude that the explorer role was more boring than the other roles, especially when other data indicates otherwise.

The Geography Expert Role

The contrast between data from the explorer and geography expert roles is fairly sharp. For the geography expert role, *I felt that I had to concentrate to do well in the game* (S10) ($p = 0.0051$) and *I felt an increase of my pulse while playing* (S12) ($p = 0.0233$) showed significant results. These statements were the same as those pointed out for the expert role but with opposite responses. While explorers were significantly more likely to feel like they needed to concentrate and notice an increase in their pulse, geography experts reported the opposite. Only 54% of geography experts reported the need to concentrate, while 87% of players with other roles did. Only 8% of geography experts felt an increase in their pulse while playing, compared to 48% among other roles. These numbers paint a fairly bleak picture of the excitement of the geography expert role. However, it should be noted that *there were no significant differences in the enjoyment, focus while playing, or perceived learning effect of geography experts.*

Compared to the other roles, the geography expert role had a problem with a lack of excitement and feelings of usefulness. However, we believe the jigsaw method mitigated this somewhat (see Section 32.2). One clear takeaway from this data is the need for roles that are all sufficiently engaging when creating games where players' roles are significantly different. Should this project continue, we recommend taking steps to increase the geography expert's workload by including more necessary information in their info bank. We also recommend making their tools easier to use. Based on feedback and our observations, it did not seem like many players used the historical map. One participant mentioned its difficulty of use, which we believe was the main reason it did not see much use. This issue limited the usefulness of the role even more.

The History Expert Role

While history experts also had access to information about vehicle and photography technology. According to our observations, most of their time was spent navigating and reading their extensive information bank about historical events. When evaluating the statement *I did not try especially hard to do well in escapade* (S2), 100% of history experts disagreed, a significant difference from the 65% of other roles ($p = 0.0418$). This result indicates that history experts might have had to try harder than other roles to find the information necessary to solve a task.

Another striking difference between history experts and other roles was their interest in the history course. When asked about their interest level (Q6), 90% responded with a 4 or 5 (5 representing the most interested), while only 46% of other roles did so ($p = 0.0446$). This result indicates that players who already had an interest in the history course were more likely to choose the history role than others when arriving at the role selection screen. Before the experiment, we had not considered what would make players choose a specific role, but it makes sense that players interested in history are more likely to want the role of "history expert". This finding might be explained by Gee's principle of *identity* [35] (see Chapter 11). Taking on the identity of a history expert might feel extra good for someone interested in history. Interestingly, there were no significant differences in the interest in history as a theme when comparing history experts to other roles. This difference could mean that the history expert role was not chosen due to interest in history after all.

32.5 Summary

This chapter discussed the experiment results, combining data from the multiple-choice questions, open-ended questions, and our observations. We have compared our results to what was

expected based on existing theory. We have also suggested causes for some of the results obtained and presented multiple takeaways from the project. Overall, the game was very popular with participants, and we saw good results in motivation, enjoyment, engagement and perceived learning effect.

The participants in the jigsaw class rated the game's overall value higher than their counterparts in the non-jigsaw class and reported a higher perceived learning effect. Participants with a prior interest in video games and history had a significantly more positive experience than others, with engagement and motivation especially affected. There were no significant differences between players' experiences in three- and four-player groups. The explorer role saw significantly more signs of engagement than the others, while the opposite was true for the geography expert role. Players with the history expert role were more likely to be interested in the history course and tried especially hard to do well in the game.

We will conclude the findings of this project in the following chapter. The research questions presented in Chapter 3 will also be answered using the takeaways presented in this chapter.

Chapter 33

Conclusion

This chapter concludes the creation, development, and testing of Escapade, our collaborative learning game prototype. The chapter will provide answers to research questions presented at the start of the project and will finish with an evaluation of our research goal.

RQ1 regarded *which elements make a cooperative learning game enjoyable, engaging and educational for players.* We arrived at a combination of game design theory, learning theory, and learning game theory. *GameFlow*, *What Makes Things Fun to Learn* and *Game Rewards* aid in making the game enjoyable, while *The Ways of Learning* and *The Jigsaw Classroom* can be used to strengthen the learning aspect of a game. Learning game-specific theory is also useful, such as *Learning by Design* and *LEAGUE.*

RQ2 was directed at *how playing our game affected players'* ***motivation*** *towards the subject presented by the game.* The player response on motivation was largely positive. Players stated that the game would be valuable to them, with the jigsaw class being especially positive. We were also surprised that over half of the players were interested in learning more about the situations pictured in the game.

RQ3 asked *to what degree does our game enable* ***collaboration*** *between multiple players in a way that* ***promotes learning****.* We tested the game with two different collaboration methods to evaluate this research question. Collaboration between players was generally good, but the jigsaw class saw more positive effects, specifically for learning. True evaluation of the learning effect was infeasible in this project, but perceived learning was generally high among players. Evaluation of the game's inclusion of the jigsaw method showed that players in the jigsaw class had higher perceived levels of learning than their counterparts.

RQ4 targets *how player* ***engagement*** *was affected by the game's collaborative elements.* Players reported that they were deeply engaged while playing the game, and we observed almost constant discussion between group members during game rounds. Engagement levels varied significantly by player role, with explorers reporting higher than the average engagement, while the opposite was true for geography experts. Players mentioned that the time per round should have been shorter to put more pressure on the team to work quickly together. This feedback was also reflected in quantitative data from the questionnaire.

RQ5 looked at *how player **enjoyment** was affected by the game's collaborative elements.* Feedback showed that players enjoyed the game irrespective of their role in the team. Players in the jigsaw class were more likely to express that they wished the game was part of the history course than in the non-jigsaw class, indicating higher overall enjoyment.

RQ6 focused on *how the **gameplay experience** was affected by a player's **interest in video games and history**.* We found that players with a high interest in video games or history experienced significantly more positive results regarding motivation, engagement, and enjoyment. They also reported that they had an easier time collaborating than those with low interest in gaming and history but reported similar levels of perceived learning. Players' interest levels in these topics had more of an impact on their experience than anticipated.

For our overall conclusion, we will evaluate the research goal presented at the beginning of this project: *to design, develop, and test a collaborative learning game that is both engaging and educational.* At the beginning of this project, we created a concept for a new collaborative learning game, Escapade. We then developed the concept into a functioning prototype and tested its effect in an experiment. Based on the answers to our research questions, we believe we have achieved our goal of creating a collaborative learning game that is engaging and educational for players.

Chapter 34

Master's Thesis Retrospective

This chapter will reflect on the project's overall process, what went well, and what has potential for improvement. There are specifically three aspects of the project that we will discuss: *prestudy*, *collaboration and development methodology*, and *results*.

34.1 Prestudy

The prestudy part of this thesis was based on work from our specialisation project [9]. This part was fundamental for concept development, game design theory, and technology choices. With guidance from our supervisor, we accumulated comprehensive knowledge from other research papers, projects, and literature. The prestudy was a source of inspiration and integral for developing the prototype of Escapade. Overall, we were content with the outcome of a thorough prestudy, which showed its value when applied in this thesis.

34.2 Collaboration and Development Methodology

Coming into this project, we started by discussing motivations and expectations. We shared many similar thoughts and work ethics, so we deemed it meaningful to form a suitable work environment. Having worked together before in other courses, we had experience with how we wanted to structure different processes. These thoughts ultimately helped us collaborate efficiently and transparently.

The development methodology used in this thesis is based on previous projects' trial and error. Our process covered everything from requirements and wireframing to code development. Great collaboration was essential to achieve a coherent methodology for our team of two. We benefited greatly by using Notion as our project overview tool. We used this software to create timelines, delegate tasks, and store documents, feedback, notes, and drafts. This way, we could, at all times, check the status of each other's work and see deadlines in the timeline.

As a consequence of good collaboration tools, remote work was allowed. For a remote communication tool or sometimes for pair programming, we used Discord. Having previous experience with these tools made our development process and cooperation more efficient. Adding agile principles to our project also worked well. Daily standups for status updates, sprints, and a

Kanban board were helpful.

One space for improvement would be to learn more about automated testing in the code. We did a lot of manual testing during development, which could be omitted for automated tests. However, due to the rapid development speed, it proved difficult with our limited experience with testing.

34.3 Results

Overall, we think the experiment yielded excellent results. The test population was ideal for our game, which generated valuable data. However, there is some room for improvement regarding the experiment. First, more thorough testing of our prototype would be ideal. During local testing, no significant technical or visual issues appeared. However, a few visual and technical bugs appeared when participants were playing. Having a system for finding the source of these issues may improve this.

Next, there are elements of the game that have room for improvement. During the experiment, some roles were not as active as others. Creating a balance between the amount of work for roles has potential for improvement. Additionally, the time of each round can be tweaked to fit each round better. While we tried to find a proper balance, we did not have enough time to test on a larger scale. Our internal tests were also conducted on another demographic than the relevant test population. We do not consider these aspects serious issues as gameplay content will organically improve through more play-testing on relevant players.

Finally, the questionnaire we used for data collection has room for improvement. Our focus for the survey was to strike a balance between insightful questions and statements and their amount. From our own experiences, long questionnaires have been cumbersome, and some resulted in imprecise answers. Admittedly, finding valuable questions and statements also proved more difficult than expected. We believe improving our questionnaire would be likely with more time for trial and error.

Chapter 35

Future Work

Our prototype worked well for the most part, but because of the time limitations of this project, we believe not all its potential was realised. This chapter outlines aspects of the game that we could improve and further experimentation.

35.1 Prototype Improvements

As discussed in Section 30.7, a few technical issues were revealed during the experiment. A natural starting point for improvements would be there. Following that, some functional requirements with lower priority were not implemented (see Section 21.1), indicating areas for improvement. Furthermore, after receiving feedback and analysing experiment results, we identified additional potential enhancements to our concept.

Improved Roles

The three roles of our prototype, explorer, an expert in history and technology, and expert in geography and flags, had different impacts, as discussed in Section 32.4. The current implementation of these roles is skewed in terms of workload, importance, and engagement. Adding improvements to these roles will be valuable. Examples of enhancements include adding more content in terms of text and images. Create new ways of navigating content, like sliders for years in a historical map. Add more crucial information only available to experts.

As results also showed, the group size of three or four did not make much of a difference. This finding means it could be worth experimenting with a fourth role instead of having two players play the explorer. This role could be inspired by GeoGuessr and include architecture, language, and flora. However, introducing more roles will add more complexity. An influential factor is to ensure the role is balanced compared to the rest. Roles also have to fit the game themes (images and questions), which means creating new themes will become more complex.

Adding support for expert roles that change depending on game themes should also be considered. Making expert fields dynamic may help ease the fit of roles to various game themes. This functionality will also make it easier to make new game themes as hints in images can be connected to a broader selection of experts.

Improved Historical Map

Another area of improvement is the map used by the *geography and flag expert*. The current prototype uses a YouTube video to display a historical map, which is not intuitive to navigate. To improve the usefulness of this role and map, an upgrade of this map should be considered.

There are various directions to enhance the map. One way could be to integrate the map into a more immersive and central part of the role. Figure 35.1 is a screenshot from *history-maps.com*, a service for historical maps with pins that describe notable events. A direction like this can be used as inspiration for Escapade as well. Depending on the implementation, this could also be combined with the *history and technology expert* as well. In that case, different information needs to be displayed depending on the role.

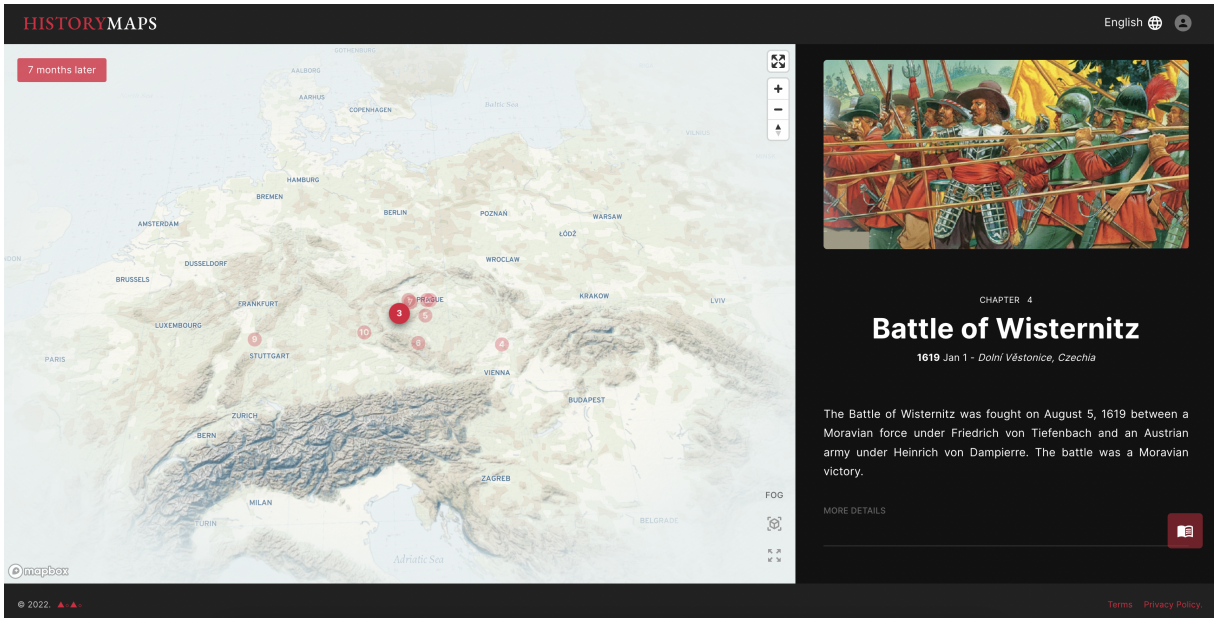


Figure 35.1: Screenshot from history-maps.com

Tutorial

While Escapade did have a tutorial which worked for our use case, it is not optimal for scalability. The tutorial should work without someone manually presenting the game. An option could be to create a video explaining the game elements. A more interactive way of giving the information could be achieved by adding guiding overlays to a playable tutorial.

A Platform for Creating Game Themes

The prototype had a system for creating game themes but was intended for developers. Creating a new platform tailored towards teachers, where they can make their game themes, would be valuable going forward. Since creating game themes in Escapade can be challenging, adding features to reduce this overhead is necessary. One option could be to add templates and examples. Having a platform where teachers can collaborate and share game themes could help reduce the workload.

Music and Audio Effects

Adding music and audio effects to games with a point scoring system can benefit classroom dynamics [61]. Music for Escapade was also mentioned as feedback from the questionnaire (see Section 30.6). As presented in Chapter 8, adding audio effects can also be a good way of increasing sensory curiosity, like in the final countdown of a round. Experimentation would be needed to find fitting music because the nature of enjoyable music is subjective.

Fantasy Element

We initially designed the prototype of Escapade with a time-travelling element in mind. As a consequence of time limits, this idea was ultimately retired. For future work, this element could be incorporated in various ways. Game introductions utilising cutscenes or animations could be an immersive way of introducing this element. More straightforward ways could be integrating it into the UI with graphics, images, or text into the UI.

User Account

Adding a system for user accounts should be considered. With players having an account, new opportunities for user progress and character customisation arise. As mentioned in Chapter 20, achievements and role-specific levels could act as additional motivational factors. Players could also unlock new customisation options to further improve personalisation.

35.2 Further Experimentation

Escapade is still in its early stages as a concept. There is a lot of potential for experimentation to improve the concept. Testing on more students would be beneficial to gather more research data and, in turn, affect statistical significance. As discussed in Chapter 28, our experiment

was conducted overtly and at a time when the classrooms' attendance rates were relatively low. The results were still generally good, but it would be helpful to exclude uncertainties that could affect the outcome. Testing the game covertly, with more participants at other times of the year, and at other schools are valuable ways of experimenting further.

To research the actual learning effect of the game, assessing the game over a more extended period is necessary. Additionally, the concept does not need to be restricted only to the history course. It would be interesting to experiment with other studies, like natural sciences, religion, or geography. The concept should also be tested on different age groups as well. Students in elementary schools, middle schools, and universities are applicable test populations for further experimentation.

Another aspect to consider further experimenting with is the jigsaw method. It could be interesting to test this idea of interdependence with other game concepts. The general results of the jigsaw class were promising, but additional research would be needed to observe "real" value in learning games.

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Appendices

A Example of a Cloud Firestore Document

```
ALVYQR: // gameCode
    canJoin: false
    created: 1651575015589
    finished: false
    hostId: "n03pld4"
    participants:
        eoqvhm: // playerId
            color: 1
            eyes: 1
            round1:
                multipleChoiceAnswer:
                ...
            ...
    ...
```

B Example Code of a Schema in Sanity

```
export default {
  name: 'gameMaps',
  title: 'Maps',
  type: 'document',
  icon: Map,
  fields: [{
              name: 'title',
              title: 'Tema',
              type: 'string',
              description: 'Temaet må være unikt',
              validation: (Rule) => Rule.required(),
            },
            {
              name: 'id',
              title: 'Id',
              type: 'number',
              description: 'Rekkefølge, lavest kommer først',
              validation: (Rule) => Rule.required(),
            },
            {
              name: 'description',
              title: 'Description',
              description: 'Beskrivelse av teamet',
              type: 'string',
            },
            {
              name: 'questionSet',
              title: 'Runde',
              type: 'array',
              of: [{ type: 'round' }],
            }]};
```

C Introductory Slides Shown Before the Experiment (Norwegian)

Plan

- Datateknologi ved NTNU (IDI)
- Introduksjon av spillet
- Dele opp så hvert lag er 3 og spille en “tutorial”
- Spille gjennom et tema i spillet
- Spørreundersøkelse

Hva er Escapade?

- Dataspill, samarbeid og læring
- Historie
- Svare på tre spørsmål basert på et bilde
  - Hva, når og hvor
  - Ulike roller
- Ingen hjelpemidler
- Spillet er en prototype
  - Kan oppstå bugs

Escapade

Kode for spillet

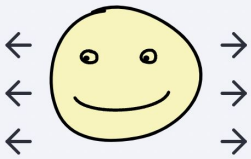
Bli med

Lag din egen Escapade

Lag et spill

Escapade

Skriv inn navn



Tilfeldig

Bli med

Gå tilbake

Escapade

Lag 1 (3 spillere) Gå ut av lag 1

He1 · Beste spilleren · Safari (deg)

Lag 2 (4 spillere) Velg lag 2

sssss · 19 spiller · Tax Verstappen · Safarooo

Lag 3 (3 spillere) Velg lag 3

asdsadasda · Stress · Fargerik

Lag 4 (3 spillere) Velg lag 4

noe · asdsadsad · DAYU

Lag 5 (3 spillere) Velg lag 5

sad sad · Test · asdasdsa

Lag 6 (3 spillere) Velg lag 6

Baaa · Wictor · Buki

Venter på at verten starter spillet

Escapade

Lag 0

Utforsker
Tid og sted

Du får se bilder og må jobbe med laget ditt for å finne ut hva bildene er av. Passer dersom du er flink til å se detaljer.

test

Ekspert
Geografi og flagg

Du vil ha tilgang til mange forskjellige flagg og kart. Dersom laget trenger å vite hvor et sted er så bør de spørre deg.

TEST
(deg)

Ekspert
Historie og teknologi

Du får oversikt over viktige historiske hendelser: når det skjedde, hvem som var involvert, og hva det gikk ut på.

W

Start spillet

Escapade

Tid igjen for denne runden:

5:56

Klikk på bildet for å vise det i fullskjerm

Runde 1/1

1. Hva er dette et bilde av?

- Amerikansk militærøving i Norge under den gamle krigen
- Norges første 17. mai etter slutten av andre verdenskrig
- Ankomst av tyske soldater under invasjonen av Norge
- Feiringer i gatene etter slutten av første verdenskrig

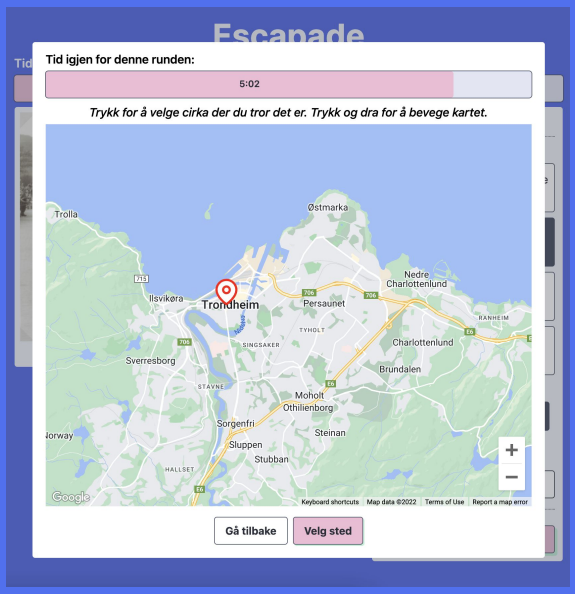
2. Når er dette?

dd/mm/yyyy

3. Hvor er dette?

Åpne kartet

Send svar



Escapade

Tid igjen for denne runden:

7:45

Innhold

Ekspert i Historie og Teknologi

I de tre første seksjonene av denne teksten finner du oversikter over en del viktige historiske hendelser. Disse er fordelt inn i tidsperiodene 1900-1949, 1950-1999 og 2000-2022. Det anbefales å bruke oversiktsmenyen til venstre for å navigere rundt, da det kan være litt upraktisk å bla gjennom all teksten manuelt.

Historie: 1900-1949

Første verdenskrig

Første verdenskrig var en verdensomspennende storkrig med utgangspunkt i Europa som varte fra 1914 til 1918.

To allianser stod mot hverandre i krigen. På den ene siden var Frankrike, Russland og Storbritannia, og fra 1917 USA, de sentrale aktørene. På den andre siden var det Tyskland, Østerrike-Ungarn og fra høsten 1914 Det osmanske riket.

Første verdenskrig er ansett som en av de dødeligste konflikter i nyere tid. Det totale antall drepte soldater og sivile er anslått til nærmere 18 millioner. Flere teknologiske nyvinninger som fly, ubåter, stridsvogner og giftgass ble tatt i bruk, og bidro til å gjøre den første globale og moderne industrielle krig så dødelig.

Escapade

Tid igjen for denne runden:

0:00

Innhold

Ekspert i Geografi og flagg

1. **Kart**
2. **Kart for hvert år siden 1850**
3. **Flagg**
    1. Afrika
    2. Asia
    3. Europa
    4. Nord-Amerika
    5. Oseania
    6. Sør-Amerika

Kart

Kart for hvert år siden 1850

Escapade

Runde: 1/1

Poeng dere fikk denne runden

1293

Veldig bra jobbet

Bla ned for å se svarene for denne runden

1. Hva er dette et bilde av?

- Amerikansk militærøving i Norge under den gamle krigen
- Norges første 17. mai etter slutten av andre verdenskrig
- Ankomst av tyske soldater under invasjonen av Norge
- Feiringer i gatene etter slutten av første verdenskrig

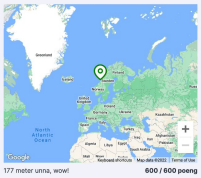
600 / 600 poeng

2. Når er dette?

17/05/1960

Fasit: **17/05/1945** **93 / 600 poeng**

3. Hvor er dette?



177 meter unna, wow! **600 / 600 poeng**

Gå videre

playescapade.com

nettskjema.no/a/**244306**

D Questionnaire (Norwegian)

ID	Spørsmål	Format
Q1	Hva heter du?	Tekst
Q2	Hva er din e-postadresse?	Tekst
Q3	Hvor gammel er du?	Tekst
Q4	Hvilket kjønn er du?	Multiple choice
Q5	Ca. hvor mange timer spiller du dataspill gjennomsninttlig i en uke?	Tekst
Q6	Hvor interessert er du i historiefaget på skolen?	Likert-skala
Q7	Hvor interessert er du i historie som tema utenfor skolen?	Likert-skala
Q8	Hvor mange var dere i gruppen deres?	Tekst
Q9	Hvilken rolle hadde du i laget?	Flervalg
Q10	Hvordan ville du beskrevet ditt bidrag til laget?	Tekst
Q11	Er det noen andre tilbakemeldinger du ønsker å gi oss?	Tekst

Table D1: Alle spørsmål

ID	Utsagn
S1	Det var viktig for meg å gjøre det bra i Escapade.
S2	Jeg prøvde ikke særlig hardt å gjøre det bra i Escapade.
S3	Å spille Escapade kan gi meg noe av verdi.
S4	Å spille Escapade gjorde meg mindre motivert i faget.
S5	Mens jeg spilte fikk jeg lyst til å lære mer om noen av hendelsene det var bilde av.
S6	Jeg synes det var lett å samarbeide med laget mitt.
S7	Jeg synes at samarbeidet gjorde spillet vanskeligere.
S8	Jeg føler jeg lærte noe av å spille Escapade.
S9	Jeg følte meg fokusert under spillet.
S10	Jeg følte at jeg måtte konsentrere meg for å lykkes i spillet.
S11	Jeg synes det var kjedelig å spille Escapade.
S12	Jeg følte en økning i puls under spillet.
S13	Å spille Escapade var gøy.
S14	Jeg skulle ønske spillet var en del av historiefaget på skolen.
S15	Jeg synes det generelt var for kort tid per runde.

Table D2: Alle utsagn

E Information Participants Read Before Consenting (Norwegian)

Vil du delta i forskningsprosjektet

Collaborative Classroom Learning Games?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke virkningen av samarbeidsspill til læring i klasserommet. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Prosjektet er en masteroppgave ved NTNU i Trondheim, Fakultet for informasjonsteknologi og elektroteknikk, Institutt for datateknologi og informatikk. Formålet med prosjektet er å gjennomføre et eksperiment hvor vi undersøker virkningen samarbeidsspill kan ha på læring, motivasjon og engasjement i et klasserom. Under eksperimentet skal deltagere gruppevis spille et flerspillerdataspill vi har utviklet samt besvare spørsmål via spørreundersøkelse slik at vi kan analysere de overnevnte faktorene.

Hvem er ansvarlig for forskningsprosjektet?
Professor Alf Inge Wang ved Institutt for datateknologi og informatikk ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du blir sannsynligvis spurt siden du går på en videregående skole vi har kontaktet angående eksperimentet. Noen kontaktes også av oss direkte siden de er del av vårt egne nettverk, dette kan for eksempel gjelde medstudenter og familie.

Hva innebærer det for deg å delta?
Ved å delta i dette prosjektet er du med i et eksperiment der du bruker spillet vårt, *Escapade*, i en økt. Du vil få en introduksjon til spillet og vil svare på spørsmål angående effekten spillet har hatt på læring, engasjement og motivasjon gjennom spørreskjema.

Dine svar fra spørreskjemaet vil bli registrert elektronisk. I tillegg til spørsmål angående spillets effekt, tidligere spillerfaring og faginteresse, vil du bli spurt om navn, epostadresse, kjønn og alder. All data som kan bli brukt til å identifisere deg vil bli slettet ved prosjektets slutt, eller tidligere dersom du ber om det. Dersom det er ønskelig kan foreldre se spørreskjema på forhånd ved å ta kontakt med oss.

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

De som ikke ønsker å delta vil få et alternativt opplegg i timen(e) det gjelder, og deltagelse vil ikke ha noen innvirkning på forholdet mellom skolen/lærer og deg, hverken i eller utenfor faget.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

Det er kun oss, forfatterne av masteroppgaven, og vår veileder som vil ha tilgang til personopplysningene innhentet i eksperimentet. Navn og kontaktinformasjon vil lagres i en separat liste fra resten av dataen, der de erstattes med en identifikasjonskode. Dataen lagres sikkert i NTNU sine tjenester i henhold med universitetets rammeverk for lagring av sensitiv data

(https://i.ntnu.no/wiki/-/wiki/English/Data+storage+guide). Spørreundersøkelsen drives av Nettskjema.no (https://i.ntnu.no/wiki/-/wiki/Norsk/Nettskjema).

I den ferdigstilte masteroppgaven kan følgende persondata bli publisert: Kjønn, alder, tidligere spillerfaring og faginteresse. Dette vil i så fall ikke bli knyttet til individuelle deltagere, og vil derfor ikke kunne brukes til å identifisere deltagere.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Opplysningene anonymiseres når prosjektet avsluttes/oppgaven er godkjent, noe som etter planen er 16.06.2022. Navn og kontaktinformasjon vil da slettes, og all annen data vil anonymiseres.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Institutt for datateknologi og informatikk ved NTNU har Personverntjenester vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

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

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

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

- Forfatterne av masteroppgaven:
  - Wictor Zhao – wictorz@stud.ntnu.no
  - Jakob Endrestad Kielland – jakobek@stud.ntnu.no
- Veileder:
  - Alf Inge Wang – alf.inge.wang@ntnu.no
- Vårt personvernombud:
  - Thomas Helgesen – thomas.helgesen@ntnu.no

Hvis du har spørsmål knyttet til Personverntjenester sin vurdering av prosjektet, kan du ta kontakt med:

- Personverntjenester på epost (personverntjenester@sikt.no) eller på telefon: 53 21 15 00.

Med vennlig hilsen

Alf Inge Wang (Forsker/veileder)	Wictor Zhao (Forfatter)	Jakob Endrestad Kielland (Forfatter)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *Collaborative Classroom Learning Games*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i spørreskjema

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

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(Signert av prosjektdeltaker, dato)

F Full Result Tables

Included are the full tables which contain answers on all statements, both by all participants, and grouped by the jigsaw and non-jigsaw group, gaming interest, interest for the history subject, interest for history in general, and the different roles available in the game. Each table includes the p-value calculated by applying the Mann-Whitney U test [17] to the sets of answers from both groups. All answers were originally given with a five-point Likert scale [16], but are presented with a three-point Likert scale for readability. The five-point answers were used for all calculations.

In addition to the Mann-Whitney U test scores, three of the tables feature a correlation score. This concerns the tables gaming interest, interest for the history subject, and the interest for history in general. These scores show the correlation between participants' said interest and each question. The correlation scores were calculated using Spearman's rank correlation coefficient [18], and are not intended to be used as a measure of significance, but rather to compare the correlation to different factors for statements where multiple factors impart a significant difference.

When creating two subgroups for each factor the following definitions are used:

- Jigsaw method: The jigsaw group is the first class, who were supplied rules which take advantage of the jigsaw method, the non-jigsaw group was the second class, who were not.
- Gaming interest: Low interest constitutes spending less than or equal to two hours per week playing video games. High interest constitutes spending more than two hours.
- Interest for the history subject in school: Participants in the low interest group responded with 1-3 (very low-neutral) when asked about their interest for the history subject. Participants in the high interest group responded with 4 or 5 (some interest or significant interest).
- Interest for history in general: Participants in the low interest group responded with 1-3 (very low-neutral) when asked about their interest for history in general. Participants in the high interest group responded with 4 or 5 (some interest or significant interest).
- Group size: All players were either part of 3-player groups or 4-player groups, which are the two categories used here.

- Roles: Each role is compared to all other roles. When examining the explorer role, for example, players who had the explorer role are compared with all other players.

#	Statements	All participants (n=36)		
		Disagree	Neutral	Agree
Q6	What is your interest level for the history course at school?	11%	31%	58%
Q7	What is your interest level for history outside of school?	19%	25%	56%
S9	I felt that I was focused while playing	3%	14%	83%
S10	I felt that I had to concentrate to do well in the game	0%	25%	75%
S11	I thought it was boring to play Escapade	94%	6%	0%
S12	I felt an increase of my pulse while playing	44%	22%	33%
S13	Playing Escapade was fun	0%	19%	81%
S15	Generally, I thought there was too little time each round	78%	17%	6%
S8	I felt that I learned something from playing Escapade	6%	11%	83%
S1	It was important for me to do well in Escapade	3%	22%	75%
S3	Playing Escapade can be of some value to me	14%	14%	72%
S2	I did not try especially hard to do well in Escapade	75%	19%	6%
S4	Playing Escapade made me less motivated in the course	92%	3%	6%
S5	While I played, I wanted to learn more about some of the situations in the pictures	14%	31%	56%
S14	I wish the game was a part of the history course at school	3%	14%	83%
S6	I felt it was easy to cooperate with my team	3%	14%	83%
S7	I felt that cooperation made the game harder	56%	31%	14%

Table F1: Statements from all participants

#	Statements	Jigsaw grouping	Gaming interest		History interest (subject)		History interest (theme)		Group size	Explorer	Geography expert	History Expert
		P-value	*P-value*	*Corr.*	*P-value*	*Corr.*	*P-value*	*Corr.*	*P-value*	*P-value*	*P-value*	*P-value*
Q6	What is your interest level for the history course at school?	0.119	***0.052***	0.315	*N/A*	*N/A*	***0.014***	0.470	***0.026***	0.295	0.154	***0.045***
Q7	What is your interest level for history outside of school?	0.413	***0.024***	0.503	***0.009***	0.470	*N/A*	*N/A*	***0.078***	0.401	0.305	0.203
S9	I felt that I was focused while playing	0.179	0.224	0.165	***0.022***	0.482	***0.007***	0.470	0.492	0.492	0.136	0.111
S10	I felt that I had to concentrate to do well in the game	0.134	0.444	-0.139	0.436	0.034	0.480	-0.072	0.281	***0.084***	***0.005***	0.106
S11	I thought it was boring to play Escapade	0.480	0.159	-0.243	***0.051***	-0.379	***0.078***	-0.284	0.138	***0.061***	0.298	0.140
S12	I felt an increase of my pulse while playing	0.492	***0.058***	0.228	***0.040***	0.398	***0.045***	0.315	0.440	***0.031***	***0.023***	0.452
S13	Playing Escapade was fun	0.476	***0.062***	0.413	***0.019***	0.484	***0.036***	0.393	0.312	0.409	0.181	0.239
S15	Generally, I thought there was too little time each round	0.382	***0.066***	0.184	0.221	-0.092	0.382	-0.079	0.264	0.488	0.264	0.236
S8	I felt that I learned something from playing Escapade	***0.054***	0.258	0.062	0.405	0.121	0.405	-0.011	0.181	0.341	0.209	0.341
S1	It was important for me to do well in Escapade	0.500	***0.009***	0.440	***0.059***	0.317	0.136	0.207	0.100	0.239	0.100	0.274
S3	Playing Escapade can be of some value to me	***0.034***	***0.049***	0.259	0.492	0.127	0.147	0.216	0.271	0.429	0.363	0.436
S2	I did not try especially hard to do well in Escapade	0.166	***0.082***	-0.217	***0.004***	-0.481	***0.026***	-0.392	0.409	0.278	0.159	***0.042***
S4	Playing Escapade made me less motivated in the course	0.134	0.460	-0.143	0.291	-0.110	0.492	-0.199	0.209	0.352	0.345	0.500
S5	While I played, I wanted to learn more about some of the situations in the pictures	0.444	***0.044***	0.222	***0.012***	0.495	***0.084***	0.273	0.187	0.236	0.436	0.281
S14	I wish the game was a part of the history course at school	***0.035***	0.401	0.069	0.121	0.222	***0.027***	0.460	0.278	0.248	0.468	0.203
S6	I felt it was easy to cooperate with my team	0.189	***0.019***	0.403	0.121	0.320	***0.093***	0.242	0.159	0.390	0.468	0.425
S7	I felt that cooperation made the game harder	0.429	***0.066***	-0.391	***0.012***	-0.475	0.159	-0.243	0.401	0.401	0.248	0.156

Table F2: P-values and correlation of all factors

#	Statements	Jigsaw class (n=16)			Non-jigsaw class (n=20)			
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*
Q6	What is your interest level for the history course at school?	19%	31%	50%	5%	30%	65%	*0.1190*
Q7	What is your interest level for history outside of school?	13%	31%	56%	25%	20%	55%	*0.4129*
S9	I felt that I was focused while playing	0%	19%	81%	5%	10%	85%	*0.1788*
S10	I felt that I had to concentrate to do well in the game	0%	19%	81%	0%	30%	70%	*0.1335*
S11	I thought it was boring to play Escapade	100%	0%	0%	90%	10%	0%	*0.4801*
S12	I felt an increase of my pulse while playing	50%	19%	31%	40%	25%	35%	*0.4920*
S13	Playing Escapade was fun	0%	19%	81%	0%	20%	80%	*0.4761*
S15	Generally, I thought there was too little time each round	75%	25%	0%	80%	10%	10%	*0.3821*
S8	I felt that I learned something from playing Escapade	0%	13%	88%	10%	10%	80%	0.0537
S1	It was important for me to do well in Escapade	0%	13%	88%	5%	30%	65%	*0.5000*
S3	Playing Escapade can be of some value to me	0%	13%	88%	25%	15%	60%	***0.0336***
S2	I did not try especially hard to do well in Escapade	69%	31%	0%	80%	10%	10%	*0.1660*
S4	Playing Escapade made me less motivated in the course	94%	0%	6%	90%	5%	5%	*0.1335*
S5	While I played, I wanted to learn more about some of the situations in the pictures	19%	25%	56%	10%	35%	55%	*0.4443*
S14	I wish the game was a part of the history course at school	6%	0%	94%	0%	25%	75%	***0.0351***
S6	I felt it was easy to cooperate with my team	0%	25%	75%	5%	5%	90%	*0.1894*
S7	I felt that cooperation made the game harder	56%	31%	13%	55%	30%	15%	*0.4286*

Table F3: Statements and p-values for participants based on jigsaw grouping

#	Statements	Low gaming interest (n=17)			High gaming interest (n=19)				
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*	*Correlation*
Q6	What is your interest level for the history course at school?	6%	47%	47%	16%	16%	68%	***0.0516***	0.3149
Q7	What is your interest level for history outside of school?	29%	35%	35%	11%	16%	74%	***0.0239***	0.5031
S9	I felt that I was focused while playing	6%	12%	82%	0%	16%	84%	*0.2236*	0.1649
S10	I felt that I had to concentrate to do well in the game	0%	24%	76%	0%	26%	74%	*0.4443*	-0.1389
S11	I thought it was boring to play Escapade	94%	6%	0%	95%	5%	0%	*0.1587*	-0.2427
S12	I felt an increase of my pulse while playing	59%	18%	24%	32%	26%	42%	***0.0582***	0.2283
S13	Playing Escapade was fun	0%	29%	71%	0%	11%	89%	***0.0618***	0.4126
S15	Generally, I thought there was too little time each round	82%	12%	6%	74%	21%	5%	***0.0655***	0.1841
S8	I felt that I learned something from playing Escapade	6%	18%	76%	5%	5%	89%	0.2578	0.0622
S1	It was important for me to do well in Escapade	6%	29%	65%	0%	16%	84%	***0.0091***	0.4403
S3	Playing Escapade can be of some value to me	18%	29%	53%	11%	0%	89%	***0.0485***	0.2588
S2	I did not try especially hard to do well in Escapade	71%	18%	12%	79%	21%	0%	***0.0823***	-0.2172
S4	Playing Escapade made me less motivated in the course	88%	6%	6%	95%	0%	5%	*0.4602*	-0.1427
S5	While I played, I wanted to learn more about some of the situations in the pictures	18%	41%	41%	11%	21%	68%	***0.0436***	0.2222
S14	I wish the game was a part of the history course at school	0%	18%	82%	5%	11%	84%	*0.4013*	0.0691
S6	I felt it was easy to cooperate with my team	6%	18%	76%	0%	11%	89%	***0.0188***	0.4032
S7	I felt that cooperation made the game harder	47%	35%	18%	63%	26%	11%	***0.0655***	-0.3912

Table F4: Statements, p-values, and correlation for participants based on gaming interest

#	Statements	Low interest in subject (n=15)			High interest in subject (n=21)				
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*	*Correlation*
Q6	What is your interest level for the history course at school?	27%	73%	0%	0%	0%	100%	*N/A*	N/A
Q7	What is your interest level for history outside of school?	33%	33%	33%	10%	19%	71%	***0.0089***	0.4698
S9	I felt that I was focused while playing	7%	20%	73%	0%	10%	90%	***0.0222***	0.4816
S10	I felt that I had to concentrate to do well in the game	0%	33%	67%	0%	19%	81%	*0.4364*	0.0343
S11	I thought it was boring to play Escapade	87%	13%	0%	100%	0%	0%	***0.0505***	-0.3785
S12	I felt an increase of my pulse while playing	67%	13%	20%	29%	29%	43%	***0.0401***	0.3983
S13	Playing Escapade was fun	0%	33%	67%	0%	10%	90%	***0.0192***	0.4843
S15	Generally, I thought there was too little time each round	73%	20%	7%	81%	14%	5%	*0.2207*	-0.0924
S8	I felt that I learned something from playing Escapade	7%	7%	87%	5%	14%	81%	0.4052	0.1212
S1	It was important for me to do well in Escapade	7%	20%	73%	0%	24%	76%	***0.0594***	0.3173
S3	Playing Escapade can be of some value to me	13%	20%	67%	14%	10%	76%	*0.4920*	0.1266
S2	I did not try especially hard to do well in Escapade	60%	27%	13%	86%	14%	0%	***0.0037***	-0.4805
S4	Playing Escapade made me less motivated in the course	93%	0%	7%	90%	5%	5%	*0.2912*	-0.1096
S5	While I played, I wanted to learn more about some of the situations in the pictures	20%	40%	40%	10%	24%	67%	***0.0122***	0.4954
S14	I wish the game was a part of the history course at school	7%	7%	87%	0%	19%	81%	*0.1210*	0.2219
S6	I felt it was easy to cooperate with my team	7%	7%	87%	0%	19%	81%	*0.1210*	0.3198
S7	I felt that cooperation made the game harder	40%	33%	27%	67%	29%	5%	***0.0119***	-0.4748

Table F5: Statements, p-values, and correlation for participants based on interest for the history subject

#	Statements	Low interest in theme (n=16)			High interest in theme (n=20)				
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*	*Correlation*
Q6	What is your interest level for the history course at school?	25%	38%	38%	0%	25%	75%	***0.0136***	0.4698
Q7	What is your interest level for history outside of school?	44%	56%	0%	0%	0%	100%	*N/A*	N/A
S9	I felt that I was focused while playing	6%	25%	69%	0%	5%	95%	***0.0071***	0.4698
S10	I felt that I had to concentrate to do well in the game	0%	31%	69%	0%	20%	80%	*0.4801*	-0.0720
S11	I thought it was boring to play Escapade	88%	13%	0%	100%	0%	0%	***0.0778***	-0.2837
S12	I felt an increase of my pulse while playing	69%	6%	25%	25%	35%	40%	***0.0446***	0.3146
S13	Playing Escapade was fun	0%	31%	69%	0%	10%	90%	***0.0359***	0.3929
S15	Generally, I thought there was too little time each round	75%	13%	13%	80%	20%	0%	*0.3821*	-0.0785
S8	I felt that I learned something from playing Escapade	6%	13%	81%	5%	10%	85%	0.4052	-0.0106
S1	It was important for me to do well in Escapade	6%	25%	69%	0%	20%	80%	*0.1357*	0.2071
S3	Playing Escapade can be of some value to me	25%	19%	56%	5%	10%	85%	*0.1469*	0.2156
S2	I did not try especially hard to do well in Escapade	63%	25%	13%	85%	15%	0%	***0.0262***	-0.3922
S4	Playing Escapade made me less motivated in the course	88%	6%	6%	95%	0%	5%	*0.4920*	-0.1986
S5	While I played, I wanted to learn more about some of the situations in the pictures	25%	25%	50%	5%	35%	60%	***0.0838***	0.2734
S14	I wish the game was a part of the history course at school	6%	19%	75%	0%	10%	90%	***0.0268***	0.4601
S6	I felt it was easy to cooperate with my team	6%	6%	88%	0%	20%	80%	***0.0934***	0.2424
S7	I felt that cooperation made the game harder	44%	44%	13%	65%	20%	15%	*0.1587*	-0.2434

Table F6: Statements, p-values, and correlation for participants based on interest for history in general

#	Statements	3-person group (n=23)			4-person group (n=13)			
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*
Q6	What is your interest level for the history course at school?	13%	39%	48%	8%	15%	77%	***0.0262***
Q7	What is your interest level for history outside of school?	30%	17%	52%	0%	38%	62%	***0.0778***
S9	I felt that I was focused while playing	4%	13%	83%	0%	15%	85%	*0.4920*
S10	I felt that I had to concentrate to do well in the game	0%	22%	78%	0%	31%	69%	*0.2810*
S11	I thought it was boring to play Escapade	91%	9%	0%	100%	0%	0%	*0.1379*
S12	I felt an increase of my pulse while playing	43%	26%	30%	46%	15%	38%	*0.4404*
S13	Playing Escapade was fun	0%	22%	78%	0%	15%	85%	*0.3121*
S15	Generally, I thought there was too little time each round	74%	17%	9%	85%	15%	0%	*0.2643*
S8	I felt that I learned something from playing Escapade	0%	13%	87%	15%	8%	77%	0.1814
S1	It was important for me to do well in Escapade	0%	17%	83%	8%	31%	62%	*0.1003*
S3	Playing Escapade can be of some value to me	13%	17%	70%	15%	8%	77%	*0.2709*
S2	I did not try especially hard to do well in Escapade	74%	22%	4%	77%	15%	8%	*0.4090*
S4	Playing Escapade made me less motivated in the course	91%	4%	4%	92%	0%	8%	*0.2090*
S5	While I played, I wanted to learn more about some of the situations in the pictures	9%	43%	48%	23%	8%	69%	*0.1867*
S14	I wish the game was a part of the history course at school	4%	9%	87%	0%	23%	77%	*0.2776*
S6	I felt it was easy to cooperate with my team	0%	9%	91%	8%	23%	69%	*0.1587*
S7	I felt that cooperation made the game harder	57%	26%	17%	54%	38%	8%	*0.4013*

Table F7: Statements and p-values for participants based on group size

#	Statements	Had explorer role (n=13)			Had other role (n=23)			
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*
Q6	What is your interest level for the history course at school?	15%	31%	54%	9%	30%	61%	*0.2946*
Q7	What is your interest level for history outside of school?	23%	23%	54%	17%	26%	57%	*0.4013*
S9	I felt that I was focused while playing	0%	15%	85%	4%	13%	83%	*0.4920*
S10	I felt that I had to concentrate to do well in the game	0%	15%	85%	0%	30%	70%	***0.0838***
S11	I thought it was boring to play Escapade	85%	15%	0%	100%	0%	0%	***0.0606***
S12	I felt an increase of my pulse while playing	23%	23%	54%	57%	22%	22%	***0.0314***
S13	Playing Escapade was fun	0%	23%	77%	0%	17%	83%	*0.4090*
S15	Generally, I thought there was too little time each round	85%	8%	8%	74%	22%	4%	*0.4880*
S8	I felt that I learned something from playing Escapade	0%	8%	92%	9%	13%	78%	0.3409
S1	It was important for me to do well in Escapade	0%	15%	85%	4%	26%	70%	*0.2389*
S3	Playing Escapade can be of some value to me	15%	8%	77%	13%	17%	70%	*0.4286*
S2	I did not try especially hard to do well in Escapade	69%	15%	15%	78%	22%	0%	*0.2776*
S4	Playing Escapade made me less motivated in the course	85%	0%	15%	96%	4%	0%	*0.3520*
S5	While I played, I wanted to learn more about some of the situations in the pictures	8%	31%	62%	17%	30%	52%	*0.2358*
S14	I wish the game was a part of the history course at school	0%	15%	85%	4%	13%	83%	*0.2483*
S6	I felt it was easy to cooperate with my team	0%	15%	85%	4%	13%	83%	*0.3897*
S7	I felt that cooperation made the game harder	62%	15%	23%	52%	39%	9%	*0.4013*

Table F8: Statements and p-values for participants with the explorer role

#	Statements	Had geography exp. role (n=13)			Had other role (n=23)			
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*
Q6	What is your interest level for the history course at school?	15%	46%	38%	9%	22%	70%	*0.1539*
Q7	What is your interest level for history outside of school?	15%	23%	62%	22%	26%	52%	*0.3050*
S9	I felt that I was focused while playing	8%	23%	69%	0%	9%	91%	*0.1357*
S10	I felt that I had to concentrate to do well in the game	0%	46%	54%	0%	13%	87%	***0.0051***
S11	I thought it was boring to play Escapade	100%	0%	0%	91%	9%	0%	*0.2981*
S12	I felt an increase of my pulse while playing	69%	23%	8%	30%	22%	48%	***0.0233***
S13	Playing Escapade was fun	0%	15%	85%	0%	22%	78%	*0.1814*
S15	Generally, I thought there was too little time each round	85%	15%	0%	74%	17%	9%	*0.2643*
S8	I felt that I learned something from playing Escapade	8%	15%	77%	4%	9%	87%	0.2090
S1	It was important for me to do well in Escapade	8%	31%	62%	0%	17%	83%	*0.1003*
S3	Playing Escapade can be of some value to me	8%	15%	77%	17%	13%	70%	*0.3632*
S2	I did not try especially hard to do well in Escapade	62%	38%	0%	83%	9%	9%	*0.1587*
S4	Playing Escapade made me less motivated in the course	100%	0%	0%	87%	4%	9%	*0.3446*
S5	While I played, I wanted to learn more about some of the situations in the pictures	15%	23%	62%	13%	35%	52%	*0.4364*
S14	I wish the game was a part of the history course at school	8%	8%	85%	0%	17%	83%	*0.4681*
S6	I felt it was easy to cooperate with my team	8%	8%	85%	0%	17%	83%	*0.4681*
S7	I felt that cooperation made the game harder	46%	38%	15%	61%	26%	13%	*0.2483*

Table F9: Statements and p-values for participants with the geography expert role

#	Statements	Had history expert role (n=10)			Had other role (n=26)			
		Disagree	Neutral	Agree	Disagree	Neutral	Agree	*P-value*
Q6	What is your interest level for the history course at school?	0%	10%	90%	15%	38%	46%	***0.0446***
Q7	What is your interest level for history outside of school?	20%	30%	50%	19%	23%	58%	*0.2033*
S9	I felt that I was focused while playing	0%	0%	100%	4%	19%	77%	*0.1112*
S10	I felt that I had to concentrate to do well in the game	0%	10%	90%	0%	31%	69%	*0.1056*
S11	I thought it was boring to play Escapade	100%	0%	0%	92%	8%	0%	*0.1401*
S12	I felt an increase of my pulse while playing	40%	20%	40%	46%	23%	31%	*0.4522*
S13	Playing Escapade was fun	0%	20%	80%	0%	19%	81%	*0.2389*
S15	Generally, I thought there was too little time each round	60%	30%	10%	85%	12%	4%	*0.2358*
S8	I felt that I learned something from playing Escapade	10%	10%	80%	4%	12%	85%	0.3409
S1	It was important for me to do well in Escapade	0%	20%	80%	4%	23%	73%	*0.2743*
S3	Playing Escapade can be of some value to me	20%	20%	60%	12%	12%	77%	*0.4364*
S2	I did not try especially hard to do well in Escapade	100%	0%	0%	65%	27%	8%	***0.0418***
S4	Playing Escapade made me less motivated in the course	90%	10%	0%	92%	0%	8%	*0.5000*
S5	While I played, I wanted to learn more about some of the situations in the pictures	20%	40%	40%	12%	27%	62%	*0.2810*
S14	I wish the game was a part of the history course at school	0%	20%	80%	4%	12%	85%	*0.2033*
S6	I felt it was easy to cooperate with my team	0%	20%	80%	4%	12%	85%	*0.4247*
S7	I felt that cooperation made the game harder	60%	40%	0%	54%	27%	19%	*0.1562*

Table F10: Statements and p-values for participants with the history expert role

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