



NTNU – Trondheim
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Science and Technology

Motion Capture in Educational Games

A Study of the Effects in Motivation,
Engagement and Learning

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Problem Description

This project was given to a student to be in charge of developing an educational game to be played by young students. The project is done in cooperation with Cyberlab, a Norwegian developer of serious games. The student will continue the work performed in past semester and expand it to a more finished product. The project requires studying past literature in order to have a formal basis of the different design decisions. The game needs to interact with the players through the use of a motion capture device, namely Microsoft's Kinect. After the prototype has been finished several empirical studies with the game's target audience will take place in order to evaluate the game and gather data, focusing on the effects of motion capture in educational games.

Assignment given: 11th January 2013

Supervisor: Alf Inge Wang

Acknowledgments

During this project I had the opportunity to work and get help from very talented people that had a huge impact in the development of the game prototype and the research undertaken in this thesis.

First, I would like to thank my supervisor Alf Inge Wang for helping me during the research that took place in the project and the discussion of many of the game concepts I had in mind. As well for going the extra mile by supporting me getting participants when the game prototype was ready to be tested.

I also thank Tor Ivar Eikaas and Frank Jakobsen from Cyberlab for trusting me with this project and their constant help with game ideas and problems that arose during the development of the game.

Thanks as well to all the participants who agreed to share a part of their time to play the game prototype and respond to my questionnaires and interviews. Their participation was of vast importance for the scientific research of the project.

Finally, I thank Eeva-Leena, my girlfriend, for not letting me give up during the year I worked with this game and for proofreading the thesis before it was handed in.

Abstract

The introduction of motion capture in the everyday gaming has changed the way players interact with the games. The effects of motion capture in educational games has not been addressed sufficiently. There are different issues that need to be studied, such as motivation, learning and engagement in these kind of games, the role of a social component in them, and the re-usability that could be given for employing them in different learning domains.

During this thesis I address the previously mentioned research topics. I develop a motion based educational game prototype which is used for a case study where the experiences of the players are captured and analyzed in order to find valuable information. Moreover I also perform a literature study in order to find experiences of other authors with serious games and motion capture in order to make sure that the prototype is build with a right theory background, and as well find information that could contribute to accomplishing the research goals.

The results indicate that motion based educational games are an effective pedagogical tool among kids who shown high levels of motivation, engagement and learning. Moreover, multiplayer game modes seem to be preferred and have deeper effects among the player. The game shown here also shows reusability of components for motion based educational games that fall under the classification genre.

Acronyms

GQM	Goal Question Metric
IDI	Department of Computer and Information Science
IME	Faculty of Information Technology, Mathematics and Electrical Engineering
LED	Light-emitting Diode
MVC	Model-View-Controller
NTNU	Norwegian University of Science and Technology
P1	Player 1
P2	Player 2
RQ	Research Question
SFO	Skolefritidsordning
UML	Unified Modeling Language
XML	Extensible Mark-up Language

Preface

The present master's thesis has been elaborated by me, José de Jesús Luis González Ibáñez during the spring semester of 2013. The project is the conclusion to my master's degree studies in information systems imparted at the Norwegian University of Science and Technology with the Department of Computer and Information Science under the supervision of Alf Inge Wang.

In this thesis I create a prototype of a motion based educational game having as a context the waste separation process for the recycling of materials in Trondheim. The experiences obtained during the elaboration of the prototype and its testing with users are used to suggest the effects of motion capture in educational games in the players and the opportunities of reusing the same concept in other educational domains.

The project was developed with the company Cyberlab. The main game concept was established beforehand by Cyberlab, and I discussed several ideas in order to provide more functionality for the game. The final prototype is delivered to them so they can continue towards the completion of a final product that they can release to the public.

Trondheim, June 11th, 2013

José de Jesús Luis González Ibáñez

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Part I

Introduction

Chapter 1

Thesis Structure

This thesis is structured according to the different elements that make the master project. For an easier identification of these elements I decided to divide this document in different parts which are described in the following sections.

1.1 Introduction

This part is composed of two chapters that introduce important information about the nature of the project undertaken during this master's thesis.

Thesis Information Provides the reader with introductory information about the context under which this master thesis is conceived. It also contains the motivation for its development and the goals it seeks to achieve.

Research This chapter describes the research goal and questions established for this project. Moreover, it also contains information of the research methodologies to be used, the data gathering techniques and the models used to validate the results obtained.

1.2 Literature Study

The chapters contained in this part describe different aspects that are of interest for the research goals proposed and the development of the game prototype that takes place in this project.

Serious Games Describes important characteristics and information about the underlying genre of the game prototype that is developed for this master's thesis.

Motion Based Technology Provides information about the technology used for the interaction that takes place between the game prototype and the players.

Social Aspect in Games Contains information regarding multiplayer games and their attractiveness for players which is one of the research topics in this project.

Games for Different Domains Mentions some of game concepts that could be reused in different domains. The present project aims to create a concept that can be reused in different learning domains.

Related Works Provides information about some projects that are related to the research and game prototype developed in this master's thesis.

Developing a Motion Based Educational Game Describes the technology and concepts used to develop the game used in this project.

1.3 Own Contribution

This part contains chapters that describe the empirical efforts undertaken during this master's thesis.

Game Prototype Describes the prototype developed for this project. It contains information regarding the game design, the requirements, software architecture and the implementation of the game.

Results Provides information regarding the evaluation of the game prototype and the opinions and experience of the evaluation's participants.

Discussion In this chapter I discuss the results obtained during the game evaluation and the literature study. It provides an answer to each of the research questions.

1.4 Conclusion

This part provides a closure to this master thesis. It is composed of two chapters that are important for the readers as they provide relevant information for future projects.

Summary Summarizes the different topics that were studied during this project.

Future Work Provides information regarding areas of improvement detected in the project regarding the nature of the game prototype and the research performed.

Chapter 2

Thesis Information

In this chapter I introduce important information regarding the nature of the thesis and work described in this report. The context in which the project is being performed is described. Afterwards the motivation for doing this project is mentioned. It also includes a description of the goals that are expected to be achieved by the different stakeholders involved in the various aspects of the work undertaken in this master's thesis.

2.1 Context

This project constitutes the master's thesis undertaken in the last year of the Master in Information Systems imparted by the Department of Computer and Information Science (IDI) in the Faculty of Information Technology, Mathematics and Electrical Engineering (IME) at the Norwegian University of Science and Technology (NTNU).

The project is a continuation of the work undertaken by me in the previous semester as part of the course TDT4501 Specialization Project, which provided the basis and preparation for the thesis being developed in this work. The thesis revisits some of the points addressed previously during the work performed in the in-depth project, but it switches its focus from a study of an educational game to the study of a motion based educational game and its effects on the players.

The game being used as the artifact for the study was conceived by Cyberlab, a Norwegian company focused on developing simulators and simulation based games for technical education and training [13], as part of their efforts to develop educational games which can be useful for society. The development of said game was my responsibility and I continued what I created during the specialization project. An important requirement was that the game would use motion capture (Microsoft Kinect) as the interaction mechanism, the reason for this is that Cyberlab wanted to explore this technology since they were just starting thinking on motion capture in their future games. The game was created from scratch and it was designed to be a pedagogical tool in the teaching of recycling in Norwegian schools for kids undertaking education in the fourth year [60].

Moreover, Cyberlab has thought on installing the game as part of an exhibition, allowing kids to play and learn when they are visiting it. It is also designed in a fashion that would

allow changing the learning concepts easily according to the necessities of Cyberlab.

2.2 Motivation

Video games are a growing industry which is expected to expand even more and become more pervasive. It has also been found that video games encourage players to learn in order to become better in the game environment or simply because the game awoke the curiosity in the learners. [26].

This learning environment provided by games is of special interest for organizations such as government or private companies that could make use of them as a tool to improve the education of society ranging from kids to professionals [55, 68]. A serious game can be considered a specialization of regulars games, but they differ by having a training or learning purpose. These games include the teams needed in a conventional game such as story, art and software behind it. However, serious games also need a team in charge of the pedagogical part of the game that has to be integrated to the story module in order to become an engaging game [68].

A phenomenon worth mentioning is that during the last console generations, video games have surprised the audience, not only because of the complexity and high level graphics they are able to portray nowadays, but also because of the other areas where they have had an interesting turn that is shifting the way games are played. Motion capture is a technology that is having a significant impact in the way players interact with the game. Since the introduction of the Nintendo Wii and its revolutionary controller, the three biggest competitors in the video game console industry have invested a great amount of resources in this technology, for instance it is expected that the new generation of Xbox by Microsoft requires the next release of Kinect, a motion capture device, in order to function [26].

This project studies serious games, in specific educational games, that use motion capture as the interaction mechanism between players and system. The research undertaken analyzes this kind of games from a general perspective, but as well it analyzes them from a social perspective by comparing the usefulness of a game when it is played as single player and multiplayer, and finally from a domain related aspect in order to identify certain types of games that can be used for different learning purposes.

This research expands the knowledge regarding the usefulness of educational games in young learners. Moreover, the game being studied also presents motion capture as the interaction mechanism, and due to the novelty of the use of this technology in video games, its effects in the engagement, motivation and learning of the players represent an important area of research that has not been addressed sufficiently.

Personally, this project represents an opportunity to be introduced into the gaming industry. It presents me with a challenging situation where besides being able to put into practice the different concepts and technical skills I have learned, it provides me with the chance of studying its effect in the players. Moreover, I consider that the educational purpose in the game valuable for society because it aims to improve the audience's learning process. I also think that this master will have a profound impact in my academic, professional and personal life with its outcomes improving each of these aspects.

2.3 Goals

The main objective of the project undertaken during this master's thesis is to conduct research in the area of video games, it will specifically focus on the study of the motivation, engagement and learning obtained through the use of motion based educational games. In order to achieve this it is important to discover how to use intrinsic motivation factors as fantasy, challenge and curiosity [32], so the game becomes appealing for the young players and its success on learning by playing increases.

The research of this thesis will also include the effectiveness of these games when they are played individually or with others in order to provide important information for the industry or other researchers regarding the design of motion based educational games. The play experience is different when it includes more than one person in the same game instance, may it be cooperatively or against each other, hence it is interesting to analyze this factor.

The research also encompasses studying in which kind of domains the same game could be used. This is important because finding games or game components that can be reused would significantly lower the developing costs of future games and ease the efforts towards their creation. This is of special interest for Cyberlab because they want a game that could be easily configured to teach concepts different to the one in which the game developed in this master is created.

Chapter 3

Research

As in any other scientific thesis, a big part of this work is focused on the research in an interesting area for Information Systems, more concretely, this thesis focuses on educational games and motion capture as the means to regulate the interaction between the players and the game. The project includes the development of a game prototype, but its purpose is to serve as a tool to undertake the research in this project. This part of the thesis includes the research questions that are to be studied in this thesis, the research methodology used, the data gathering techniques that were utilized to obtain the data needed to perform the research, and the validation models for the results obtained in this thesis.

3.1 Research Questions

This section introduces the questions subject to research during the development of the project. These questions aim to analyze the effectiveness and usefulness of motion based educational games as a tool to motivate, engage and help with the learning process of the players. It also examines the effects of this kind of games in social situations and the possibilities of reusing the same game concepts in order to be able to find out the different domains where the game could be used as a teaching and learning tool. In order to address these goals it is necessary to find suitable and concrete questions that could be measurable and answerable by the study undertaken in this project. The approach I decided to follow is the Goal Question Metric GQM.

3.1.1 The Goal Question Metric Approach

GQM is an approach used first at NASA, and has as a purpose to translate high level goals to questions that establish clearly how the goals can be attained. In addition, establishes the corresponding metrics needed to measure and answer said questions and hence the goal. The GQM is composed by three levels, these can be described as follows [9]:

Conceptual Level is composed by the Goal, and defined for an object in specific, in this case the game being developed, depending on different viewpoints and the issues of interest, and with a specific purpose.

Operational Level is represented by the Questions in GQM tree. Each goal identified in the conceptual level is decomposed into a set of questions that describe the manner in which it will be achieved.

Quantitative Level is represented by the Metrics in the GQM tree. Each question obtained in the operational level will have a metric to measure it. They are made by the data needed to answer each question and can be either objective (depends only on the object) or subjective (depends on the object and the viewpoint).

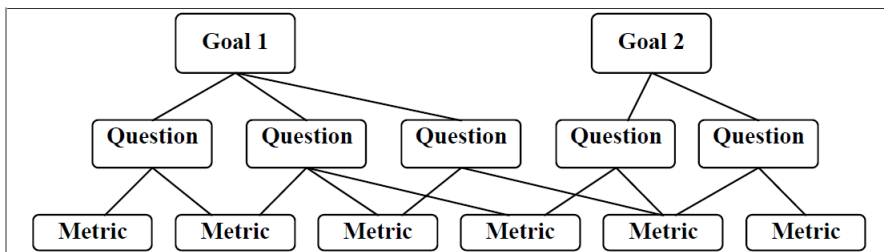


Figure 3.1: GQM Tree.

As it can be seen in Figure 3.1, the GQM is a hierarchical approach that is formed in a top-down fashion. The top most elements are represented by the goals, which in turn are decomposed into a set of questions which have a series of metrics used to answer said questions and measure them. It is interesting to note that in some cases the questions and metrics can be overlapped across different goals [9]. Even though the description of the GQM indicates that the metrics used to answer each of the questions are of a quantitative nature, the approach can also be suited for projects similar to the present one. It is only important to have in mind that the data used in the metrics are of a qualitative nature and in this case are extracted from the opinions and experiences of the users of the game which are captured in the form of questionnaires and interviews.

3.1.2 Research Questions and the GQM Approach

The research questions to be addressed in this study can be seen in Tables 3.1, 3.2 and 3.3, and they are obtained by decomposing each of the goals that were found to be the purpose of this project. The object that the GQM refers to is in this case the motion based educational game, placing interests in its effects in the education, the repercussions on the same game if played in a social manner, and the possibilities of reusing this game as a learning tool in different domains.

G1	The study seeks to establish the effects of motion capture in educational games.
RQ1.1	What are the benefits of using a motion capture system in an educational game?
Metric	Questionnaires Interview Literature Review Observation
RQ1.2	What are the effects in the motivation, engagement and learning of players who are exposed to a motion based educational game which is used as a teaching tool?
Metric	Questionnaires Interview Observation
RQ1.3	What are the advantages of learning through a motion based educational game in comparison with the traditional teacher-student interaction that takes place in a classroom?
Metric	Questionnaires Interview Literature Review

Table 3.1: Table with the goal 1 and the questions and metrics obtained.

G2	The study seeks to understand how the social aspect affects a motion based educational game.
RQ2.1	What are the players' social preferences in a motion based educational game?
Metric	Questionnaires Interview Observation
RQ2.2	How are the effects in the motivation, engagement and learning of players in a game with a social component compared to a single player game?
Metric	Interview Literature Review Observation

Table 3.2: Table with the goal 2 and the questions and metrics obtained.

G3	The study seeks to know if the same game can be used in different domains.
RQ3.1	What game concepts are fundamental for a motion based educational game to be considered fun?
Metric	Interview Literature Review Observation
RQ3.2	How can these concepts be reused for learning purposes in a different domain?
Metric	Interview Literature Review

Table 3.3: Table with the goal 3 and the questions and metrics obtained.

3.2 Research Methods

Due to the very few motion based educational games, this project required the development of a game prototype that would be used as the object of study during this thesis. In order to ground this decision with the current research methods available, I decided to follow Basili's approach for the study of Software Engineering as a science.

Basili [4] argues that Software Engineering has a need to use a scientific and engineering approach when undertaking a research activity in the area. He proposes the use of the scientific method. However, given the nature of the project the scientific method cannot be fully implemented as the research method of choice, I decided to follow Basili's advice of performing research following the variants of the scientific method that are more tailored towards software engineering projects, these variants can be described as follows [4].

The Engineering Method consists of observing existing solutions, propose better ones that try to address the problem under study, develop and improve solution from the ones that were proposed, measure it and repeat until no more improvements surface.

The Empirical Method consists on a model proposal, and the development of statistical or qualitative methods, apply said methods to a case study in order to get relevant data that will be measured and analyzed, and finally a validation of the model and possible future repetitions.

The Mathematical Method consists on the usage of mathematical and formal methods in experiments that take place with the software being developed. This method is useful for finding the best formal methods or languages to be used during a software intensive project.

As mentioned before, I have developed a game prototype, and decided to apply a combination of the engineering and empirical method proposed by Basili.

By mapping the engineering method with the work performed in this project, each of the steps needed can be described as follows:

- Observe existing solutions: First I analyze educational games during the literature review in order to detect areas of opportunity that could be exploited by the current

project. The last iteration of this game prototype is analyzed as well in order to adjust it according to the needs of Cyberlab and to the improvements detected in its last evaluation.

- **Propose better solutions:** A new version of the prototype is developed, including more functionality, and the issues detected in the previous iteration are addressed. This new solution includes a revised game design document, requirements, software architecture, and the implementation of the game.
- **Measure and repeat:** Unit and system testing is performed in order to ensure the correct performance of the game, if this is not the case then the necessary modification are implemented. This is important because the game will be tested afterwards with real users and correctness of the game prototype is highly desirable.

This research also makes use of the empirical method, and this can be observed in the following actions that took place during its development:

- **Development of qualitative methods:** In order to obtain qualitative data needed for answering the RQs I designed a survey which contains a questionnaire, and for some participants, interview questions that provide the opinions and experiences of the users of the game.
- **Apply the methods to a case study:** The questionnaires and interview obtained in the last step are both part of a survey that is applied after testing the game with real users in an environment where the final product would be used.
- **Validation Model:** The validation model used in this project is based on the evaluation of the game as case study in order to obtain information from different users. The validation model used can be seen in more detail in Section 3.8.

The different steps that make up the engineering and the empirical method can be seen during the development of the prototype and the manner in which the study was conducted. The qualitative nature of this project was the factor that persuaded me to use a combination of both methods.

3.3 Literature Review

A Literature Review is a Research Method used frequently in any kind of research. Oates [43] argues that literature review is one of the first activities undertaken by the researchers, and has as its main purpose familiarize them with the topics at hand and give credibility to their assumptions and findings.

The source of information can be books, articles, journals, web pages, newspapers, databases, conferences, and reports, given that these come from a respectable source [43].

In this project I use literature review in order to find information regarding the different topics and technologies that take part during the development in this project. The concrete topics and focus of this literature review can be seen as follows.

Platform refers to the technology used to execute the game and as well for its development. Information about the different systems that can be used as the vehicle for the execution of the game is important. Moreover, the XNA framework needs to be studied due to requirements by Cyberlab, and in order to obtain enough background information necessary to make use of this technology.

Motion Capture Systems refers to one of the main technologies to be used during the development of the game and part of the study interest. It is planned to use these kinds of systems as the mechanism that controls the interaction between the players and the game. Currently there are different motion capture technologies that can be used in conjunction with games, so a detailed study of what they consist of, and the strengths and weaknesses is needed in order to choose the best approach to be adapted into the game.

Serious Games describes the classification of the game to be developed, that is a game with a pedagogical purpose. It is necessary to find information regarding these kinds of systems, including the definition of what exactly a serious game is in order to ensure that the game to be developed during this project falls into this category. The detection of the benefits of these games would also be of interest in this study since it is part of the research focus of this project.

Social Games refers to those games that have a social component in them. In this case literature review is performed in order to find out some of the possible benefits of this play mode in comparison with single player games.

Games for Different Domains extracts important information regarding those games that can be used in different circumstance. This is a highly desirable topic for the research and the product done in this master's thesis.

3.4 Surveys

Surveys are used as a medium to collect data during a research. It gathers the same kind of data from a group of persons in an organized and systematic manner. Surveys use different mechanisms in order to get the data, which include questionnaires, interviews, observations and even documents [43]. According to Oates [43], the following are inputs needed for conducting a survey.

Data Requirements This step is related to the data that is wished to be obtained. This data can be directly related to the research questions or indirectly by gathering information corresponding to the population taking the survey.

Data Generation Method This step is based on using a qualitative method to gather data. It can either be an interview, observation, questionnaire or document study.

Sampling Frame Refers to the target population to which the survey is going to be applied.

Sampling Techniques The ways in which people are selected to participate in the survey, they can be either probabilistic (Random, Systematic, Stratified, Cluster) or non-probabilistic (Purposive, Snowball, Self-selection, Convenience).

Response Rate Refers to the action of informing about how many people answered the questionnaire or were positive about participating in the survey.

Sample Size This step decides the sample size of the population to participate in the survey.

The data recovered from this survey is directly related to the research questions previously stated. Moreover, the surveys use questionnaires and interviews in order to obtain the data from the population. In this case the population is composed of young Norwegian students, the reasoning behind this decision is that the game developed to study the effects of motion based educational games is aimed to this player profile. The sample size is one classroom where all participants participated voluntarily. The data generation techniques used in this case is a combination of multiple choice questionnaires that all the participants were asked to answer, and some selected interviews for those cases where more complex answers were needed.

3.5 Questionnaires

According to Oates [43] questionnaires are a set of predefined questions that are extensively used alongside surveys. They are especially used because it allows gathering data in an inexpensive manner and ensuring that all the participants respond to the same information.

During the data collection phase of this project I used self-administered questionnaires to get the players' opinions and experiences after being subject to gameplay in "The Recycle Game".

The questionnaires have a mixture of multiple choice and scale questions and it was designed having in mind that the participant would be kids, hence the questions used simple wording and the whole questionnaire is not too extensive in order to attract the biggest number of participants.

The questionnaire is organized in sections that extract important information useful for the research and future work that could be performed in the game. Moreover, this division also promotes a better flow through the different issues that are the interest of the study. The content and construct validity were ensured by revising the questions with my thesis supervisor Alf Inge Wang.

The first set of questions inquire personal data as gender and gaming experience. This is done in order to see if the potential players would have an easy time adopting the game as a learning alternative. Afterwards, the questions are aimed to answer the usefulness of the game as a learning process; this is done by capturing the experiences of the participants by comparing the learning process in and outside the game. The third section of the questionnaire obtains the opinion of the participants regarding their motivation towards playing the game. This information is useful since a fun game has better possibilities of

improving the learning process [32]. The next section aimed to measure the usefulness of using motion capture as the interaction mechanism in an educational game. Afterwards the users express their opinion on the social part of the game, measuring the effectiveness of the single player mode and the multiplayer mode in the game, this information will help future educational game developers in focusing in either single or multiplayer modes. Finally, the last set of questions are not directly related to the RQs, but to the game as the product in order to find areas of improvement that could be worked on in future iterations. This questionnaire is an important part of the survey used in this project to gather data important for the study. The disadvantages of doing questionnaires are that they could be underestimated by the participants and the answers given to the questions could not reflect their real opinion. However, similar issues arise in other data gathering methods.

3.6 Interviews

The surveys explained in Section 3.4 are composed alongside of the questionnaires with interviews. An interview is generally a conversation where the topic has been discussed previously between the participants, interviewer and interviewee. They are particularly useful for getting detailed information about a topic of interest and allows the researchers to ask more complex questions and issues that would have been hard to obtain through other means as it is in the case of questionnaires [43].

In order to collect some of the information regarding the players' experience with the game I decided to include interviews in the survey so I would be able to address some more complex questions that could have been hard to respond to otherwise in a questionnaire by the young users of the system.

The interview is carried out as a structured interview [43] due to the need of capturing similar issues in the survey, however the answers have not been pre-coded and they are given at the discretion of the participant. Moreover, due to the interviews being more invading and require more resources, they are not applied to the same amount of participants as it is in the case of the questionnaires. They are applied only to those participants who accept to participate and, where allowed, audio recording takes place in order to have a copy of the original discussion, in either case field notes will be taken.

The questions included in the interviews expand those found in the questionnaires or build new information relevant for the study in this project. The interviews have in total six different questions. The first question aims to find what the users think is positive about learning through a game followed by two questions regarding the fun factor issuing questions about what was fun in the game and what could be changed in order to improve the experience. Afterwards a question regarding the reusability of the game is asked in order to find out other topics that could be taught with the same game, which is of high interest for this study and for Cyberlab. Finally the last questions address the use of motion capture and the experience of playing the game from a multiplayer experience which are central topics in the research that is undertaken in this project.

The information obtained during the interviews is analyzed and the results are exposed in Chapter 11, along with those results obtained through the questionnaires.

3.7 Observation

In order to gather data that could not be detected through the use of interviews and questionnaires, I perform a general observation while the game is being tested.

According to Oates [43], observations are useful to get an insight into what people do instead of relaying on what they say they do. Moreover, it is a rather cheap data gathering technique that could be useful with almost any line of research.

The type of observation that I make use of is participant observation as a participant-observer in a covert fashion. The reason to perform it in this manner is due to my involvement in the explanation of the game to the kids and hence it requires my participation in the activities that take place during the game session at the school.

The use of the observation will allow me to collect data such as the environment in which the game was tested, the visible and verbal reaction of the children while they are playing, and other possible unforeseen situation such as technical difficulties. Due to my participation in the game test, I plan to not take notes during the game sessions because it would stop me from explaining the game rules to the players in case they need it. Moreover, by taking notes I could create an environment that could prevent the participants to act naturally. However, I plan to triangulate the data obtained in the observation with the one which I get through the use of the interviews and the questionnaires.

3.8 Validation Models

The results obtained from the evaluation of the prototype must be validated in order to measure how accurate the proposed hypothesis or the possible conclusions at which the researcher has arrived at. For validating the results obtained in this thesis I analyzed the different models proposed by Zelkowitz and Wallace [67]. The models are divided in three categories depending on the fashion they make use of the data obtained during the empirical research. These categories are described during the rest of this chapter.

3.8.1 Observational Models

Observational models are used when the data is obtained during the development process of the project. These kinds of models have the benefit of being inexpensive. The models under this category include [67]:

Project Monitoring consists on obtaining data while the development process of project takes place. Its main purpose is to study the development of a project, so it has not a clear variable to which the researcher should pay attention.

Case Study collects information while the project is being monitored. The difference with project monitoring is that the researcher puts emphasis into some interesting variables for the study. Unfortunately, this validation model cannot be replicated.

Assertion consists on having the developer acting as a researcher at the same time and applying a series of ad-hocs techniques in order to compare different technologies and conclude which one is better.

Field Study Sometimes seen as a mix between the project monitoring and case study models, the difference is that several projects are under study at the same time and the monitoring is done by an external group.

3.8.2 Historical Models

The historical models collect data from already finished projects where the information is available and analysis needs to be performed. This category is subdivided into four different methods.

Literature Search collects information from projects or papers that have been finished and with data ready to be used. The data obtained can be used to confirm a hypothesis or to strength the researcher's own data.

Legacy Data collects quantitative data from all kind of generated artifacts from past projects.

Lessons Learned generally uses already completed big projects where data was either collected or not. The data that can be obtained and studied is usually qualitative and is used to improve future developments.

Static Analysis uses already completed products and analyses quantitative data related to the structure or complexity of the product.

3.8.3 Controlled Models

These models provide several observations that allow the comparison of the obtained data and a statistical analysis. They are closely related to experimental designs used in other disciplines. There are four identified models under this category.

Replicated Experiment makes the comparison of the obtained data by executing the experiment in different subjects and under circumstances that can be adjusted according to the research needs.

Synthetic Environment Experiments consists in performing the experiments needed to collect data in environments that are not the original ones where the experiment would usually take place. Normally it includes experimenting in a lower scale in order to decrease costs. However, these experiments are difficult to scale up.

Dynamic Analysis focuses its attention on the execution of different projects and allows comparing the results between them in order to determine if they provide the same functionality, and the efficacy of each of them.

Simulation provides data by executing the project in a model of the real world where the product would normally take place allowing the control of different variables and the possibility of ignoring others that are not of interest for the researcher.

3.8.4 Validation Models Used in this Thesis

In this thesis I made use of the Case Study and Literature Review models in order to validate the obtained data.

Literature review focuses on analyzing past projects and papers in order to obtain data related to the various topics involving the research in this thesis. It places importance in serious games, the social aspect in games, games that can be used in different domains and as well technologies that are necessary for developing motion based educational games, a more concrete description can be found in Section 3.3.

The case study in this instance revolved around the measurement of the effectiveness of motion based educational games. This validation consisted of testing the game prototype with a set of potential players and collected data by making use of interviews and questionnaires. This data contained important information regarding the measurement of the motivation and engagement of the players, and at the same time it explored the social and domain component of the game. The data was analyzed and conclusions were drawn upon the experiences and opinions of the participants. The conclusions obtained through this study is expected to be able to be extrapolated, and hence be useful for future projects and be the basis of further research in the area of motion capture technologies combined with educational games.

Literature Review and Case Study were used as the validation model in this case because performing real validation with any of the controlled models, for instance, would have involved a much bigger cost in terms of time and work to be performed than the budget of twenty weeks allowed.

Part II

Literature Study

Chapter 4

Serious Games

In this chapter I describe some background information about the nature of the prototype being developed in this project, a game. It will give an overview about what a serious game is, the current uses they are having and finally some of the argued benefits that they bring to their players.

This section is of particular interest because it helps to answer RQ1.1 and RQ1.3, which focus on the benefits of educational games, by collecting the findings and experiences of other authors that have been studying similar problems. The literature review performed in this section is based on the work I carried out previously in the specialization project. However, this has been adapted in order to fit to the new research taking place during this thesis.

This chapter first gives a short definition of a serious game in Section 4.1. This is followed by a short list of areas where this kind of games are being used. Finally, in Section 4.3 I mention some of the benefits that are associated with serious games and that could be relevant for the advantages that a motion based educational game can provide.

4.1 Serious Games Definition

A video game is a piece software that brings entertainment by mixing art and story elements in it. However, in a serious game this entertainment goal present in a video game is more complex because it acts as a medium to promote education about a subject or training in a specific area [68], which could include military, healthcare, corporate training, and education [55]. These education and training functions are further explained in the following section. Moreover, Zyda [68] argues that serious video games must include pedagogy element which in turn should be attached to game story in order to create a game which is more effective as a learning tool because it entertains the players at the same time. A diagram depicting the whole definition of a serious game according to Zyda can be seen in Figure 4.1.

As it can be noted, one of the most important elements that compose a serious game is the pedagogy that has to be designed and intertwined into the game story. Tang et al. [56] argues that there are many theories, from disciplines as psychology, that have been used in

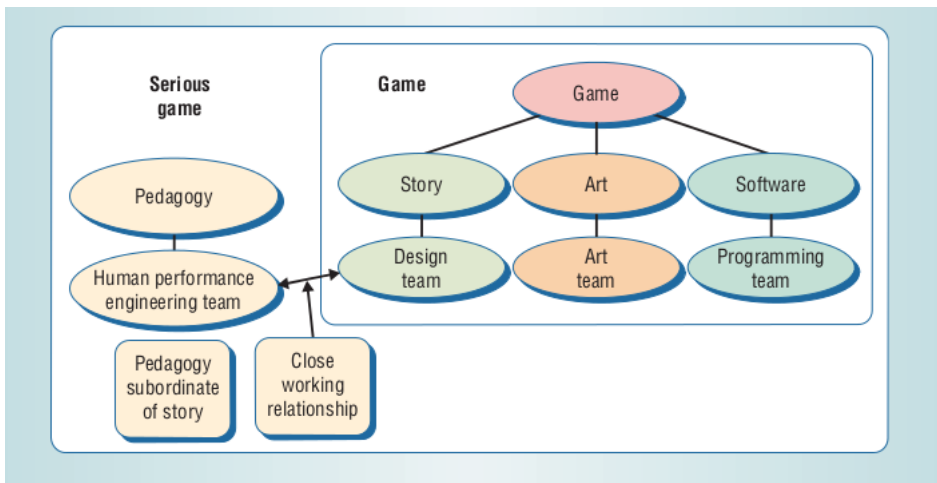


Figure 4.1: The elements of a serious game [68].

order to mix concepts from pedagogy and games so a user can learn while playing.

4.2 Current Uses of Serious Games

As mentioned before, serious games can be applied to many areas of interest, where education, military and health care are some of the more promising ones.

4.2.1 Games in Education

An area where educational games are being useful is education. The purpose of games used for education is to teach or help learning a certain concept to their players while they are engaged in the virtual world provided by the game. These types of serious games are usually referred as educational games.

Currently, educational games can be further subdivided into two specializations that are related to their target population [54].

Edutainment is targeted to kids that are undertaking education at preschool and primary school ages [8]. These games generally use the repetition of exercises as the medium to teach kids about different kind of exercises. Even though edutainment games are sometimes criticized, they have proven to be quite effective with younger audiences and persons with learning disabilities.

Higher Education games on the other hand, are dedicated to older audiences with more challenging and specific subjects. They require a more close relationship between game designers and experts in the target educational area [54].

4.2.2 Games in the Military

An organization that has shown big interest in serious games is the military [54]. The uses that they are giving to serious games are changing since they used them in the beginning for purely recruiting purposes and now they are taking advantage of the virtual worlds and simulations provided in the games to actually train their personnel in order to prepare them to confront different situations [58].

The interest of the military in serious games has been increasing in such a high degree that they have started to develop their own games in order to have tools that are specifically focused for their needs [55].

4.2.3 Games in Healthcare

Another significant sector where serious games have become increasingly important is healthcare. The games are being used for different activities such the rehabilitation of patients that take advantage of the entertainment factor in the game in order to practice different exercises they need to improve their health; moreover, they are also used for simpler matters such as informing the public of potential useful information to keep themselves healthy, to more complex matters such as training of surgeons through the use of simulations [55].

4.2.4 Games in Other Sectors

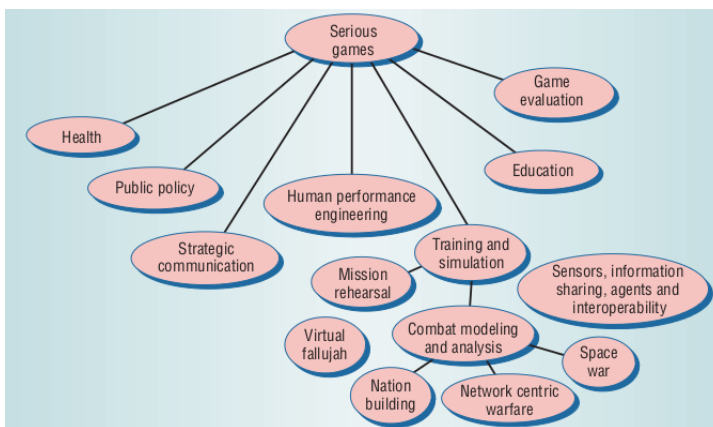


Figure 4.2: Potential areas for serious video games [68].

The use of games for serious purposes has been increasing and the areas of application have become more varied than it was before. Serious games have been adopted by corporations, and even the government, to train their employees in very specific skills needed for a certain job, to more general abilities as teamwork, communication, or strategic skills [55].

The different uses that can be given to serious games is so diverse that its industry can

become bigger than that of entertainment games because of the different benefits that they contribute and that makes them attractive for different kind of organizations [68]. A visual representation of the different fields where serious games can perform an important role can be seen in Figure 4.2.

4.3 Benefits of Serious Games

This section describes some of the benefits associated with serious games. These benefits are related directly to the players, and even though the authors do not mention that these games made use of motion capture, these benefits can be directly extrapolated to motion based educational games since they fall under the same category.

4.3.1 Serious Games Help to Build Basic Skills

Some of the benefits that serious games bring to the players are found in other kind of video games as well. According to Aguilera [14], the University of California, Los Angeles, has performed numerous studies in order to find the skills that increases by playing video games, these can be seen in the following list that also coincide with what other authors have found [55].

- Spatial perception
- Spatial recognition
- Spatial representation
- Separation of visual elements
- Psycho-motor skills

Furthermore, Griffiths [24] argues that by playing video games, players develop skills in other areas as it is math, reading and even socialization. He was also able to notice that persons with special needs were able to develop basic skills they lacked.

4.3.2 Benefits for Learning

One of the most attractive benefits provided by serious games is the possibility of learning about or training for a specific domain. The education provided by playing serious games is of high importance because it promotes learning by engaging the players through the use the interactivity they provide and at the same give the means for the users to establish goals and rehearse them [24]. The education provided by games is also stronger because it provides the opportunity to create situations centered on the learners instead of the traditional system where the teachers are the center with the students acquiring as much information as they can from them [54].

The educational value of games regarding their cognitive benefits is a topic that needs to be researched more. Squire et al. [52] argue that there is not enough information to affirm that serious games have a positive influence over the players' cognition. However, authors

such as Hogle [27] mention that thanks to the motivation provided by the games and the repetition of activities required, they can play an important role in the players' cognitive development.

4.3.3 Highly Motivated Players

Video games are also known for motivating the players to use them. Games can keep players motivated by awaking the player's curiosity by the use of different mechanisms [32]. This motivation is also affected by the game's capacity to get the player's attention through the challenges it presents to them which keeps the players in a deep concentration state while they are trying to solve them [32, 20, 27]. The motivation provided by the video games also plays an important role in the players' affinity to accomplish a task. Wright [65] argues that according to experiments performed by Pope and Palsson children who did some kind of training through the use of video games were not only able to accomplish the goals of the game, but were more motivated than other children who did not perform the training with games.

4.3.4 Simulations and Virtual Environments

One more advantage acquired with video games is that they provide to the stakeholders the possibility of having the gameplay take place in a simulated or virtual environment.

A simulation or virtual environment is a representation of the real world, which usually is simple and adaptable to the stakeholders' interests [27]. The use of simulations and virtual environments represent an important benefit for using video games with a learning or training purpose because the players are able to experiment different kind of situations and environments that could be impossible to acquire in the real world because they are physically impossible, economically prohibitive or possibly dangerous towards the players' health [55, 24, 53].

4.3.5 Other Benefits

Other benefits that could be attractive to educators, especially for those who have the responsibility of teaching young students. According to Griffiths [24] video games can be used as a monitor tool that could be useful when studying or observing the students' personality or self-esteem and self-concept development.

Other perceived benefits are related to the social interaction of the players. Gamers, as people who tend to use video games extensively are called, are seen to develop social skills rather fast.

There has also been experiments [23] regarding the effects of video games in respect to a pro-social behavior of the players. Video games that promote beneficial acts towards society are found to affect positively their players and encourage a behavior that can be attractive for society, which is achieved because video games are able to affect the cognitive, arousal and affective levels in the players.

4.4 Relation to the Thesis

The definition of serious games and as well its uses, helps me to guide the work undertaken in this master's thesis in order to ensure that the game developed in this project is educational and hence falls under the category of serious games.

Moreover, the benefits detected with serious games could be extrapolated to a motion based educational game which is developed in this project. These benefits are being reevaluated because the game makes use of motion capture as the interaction device, which could change the gameplay experience and hence the degree in which the benefits detected in serious games affect the players.

Chapter 5

Motion Based Technology

In this chapter I describe what motion capture is, the different kind of technologies available and as well the various uses that the industry has given to this technology. The use of motion capture is of high importance to this project due to it being one of the central points of the research undertaken. The literature studied in this chapter is relevant for answering RQ1.1 and RQ1.3.

This chapter is based on my previous work that was performed with the same game but other research objectives were addressed, however the literature that was studied overlaps.

5.1 Brief Definition of Motion Capture

Motion Capture is a relatively new technology which is being used as a computer interaction mechanism and, as its name describes, by capturing the movements of an object in the space, the user is able to control or manipulate elements that are displayed on a screen [45].

According to what is discussed by Dyer et al. [16], the process of capturing these movements consists on recording the position of an object, might it be alive or inert, in the space and translating this positional data into readable coordinates for a computer. Moreover, the objects whose movements are being captured can be bodies, gestures, lights or cameras. Furthermore, there is a distinction between motion capture systems depending on the manner in which the movements are captured, they could be either real-time systems, in which the movements captured are used as they are; or non-real-time systems in which the captured movements must be subject to further processing in order to use them.

Motion capture systems can also be subdivided according to the technology they use to capture the movements of objects [18]. These subdivision yields three different types of motion capture systems.

Figure 5.1 shows a graphical representation of the division of motion capture systems.

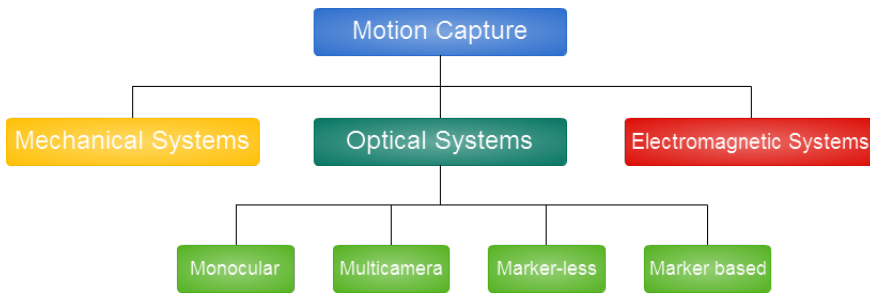


Figure 5.1: Diagram of the different types of Motion Capture.

Optical Motion Capture Systems receive optical stimuli in order to process the information about the subject's movement in the space [29]. These systems are usually further subdivided depending on the way in which the visual stimuli is received. They can be monocular, in which only one camera captures the subject movements [25]; multi-view systems make use of multiple cameras in order to have a better precision during the movement capture [25]; marker-based systems require that the object being tracked uses special equipment. They are divided into passive systems in which the subject needs to wear a special suit that the cameras can identify, or active systems in which the subject is required to put LEDs [63]; marker-less systems capture the movements of an object by calculating the position of certain joints or points on the subject [25, 29].

Mechanical Motion Capture Systems use exoskeletons with sensors at specific points. These exoskeletons consist on equipment that can be used in a certain part or the whole body of the subject [59, 18]. These kinds of systems present the advantage of being highly precise, however they also present the disadvantage of being too invasive, and it is hard to perceive the altitude of the subject [18].

Electromagnetic Motion Capture Systems are similar in some sense to mechanical and active based optical systems in the fact that the user needs to wear magnetic receivers in his body that work as sensors that capture the movements of the user. This kind of motion capture works by having the transmitter produce a magnetic field that is used by the receivers to establish the position of the body being tracked [29]. They have the disadvantage of being subject to magnetic noise [59, 29].

5.2 Uses of Motion Capture

Nowadays the use of motion capture mechanisms have become more pervasive and part of a regular person's daily life, and it is not limited to the big animation studios and research facilities as it was in its beginnings. The opportunities that this industry shift has provoked are being seen by the use of this technology in different areas that were alien towards motion capture technology. This section presents briefly some of the areas in which motion capture is being used more extensively.

5.2.1 Robotics

Research in the area of robotics has seen an interesting change with the use of motion capture systems. Their use has resulted in robots that use simpler mechanisms for movement and space navigation. El-Iaithy et al. [17] make use of motion capture, Microsoft's Kinect in this case, in a robot construction. With the aid of the RGB and depth cameras in the device they study the effectiveness of motion capture for environment recognition and navigation, object manipulation and human recognition. Their results are promising for the use of motion capture and robotics but more mature devices are still needed. Similar experiments are performed by Rakprayoon et al. [46], where Kinect is used again for obstacle detection in their robot manipulator. Their results point out that using the depth camera is more effective and economical than traditional obstacle detection with stereo cameras.

5.2.2 Human-Computer Interfaces

The use of motion capture in the field of human-computer interaction is born due to the necessity of more natural interaction mechanisms between a human and a computer, this is especially important in 3D interfaces [39]. Kinoogle developed by Boulos et al. [6] provides a motion capture based interface for controlling Google Earth using Kinect. They use motion capture for a more natural navigation of the world map and found that the manipulation of the world globe was easier than using a combination of mouse and keyboard. Another interesting result of the use of motion capture in human-computer interfaces is the creation of Leap Motion, a company soon to release their product of the same name, which uses motion capture in order to provide an alternative to the mouse and keyboard. This product is expected to ease many activities such as the navigation in a computer, digital painting, and 3D modeling among others [40].

5.2.3 Video Games

Video games have been experiencing a great change this last generation which is starting to reformulate the way in which games are played. The three biggest console companies (Nintendo, Sony and Microsoft) have incorporated motion capture in their systems and the amount of games that support these new interaction mechanisms have been raising. For instance, Microsoft describes Kinect as an interaction mechanism in which the players do not need of controllers or other devices in order to control the actions in the game. The games that are offered include puzzles, sports, shooters and even games specialized for exercising, among others [38].

The combination of video games and motion capture has helped researchers to develop serious games that use this technology. For instance at the Newcastle University, a game aimed to help rehabilitation of patients that suffered a stroke, which is called Circus Challenge, uses motion capture to regulate the interaction between the players and the game [3].

5.3 Relation to the Thesis

Motion capture is a big part of the game developed in this master thesis, hence it is useful to know the different aspects of this technology and the current uses it has. The game developed falls directly into one of the more prominent areas where motion capture is used. The information gathered is useful for the research undertaken because it gives background information related to the motivation and engagement that the players could become subject to when using motion capture. Moreover, it provides with important background information useful to know the benefits and disadvantages of the different technologies that a motion capture device could make use of.

Chapter 6

Social Aspect in Games

This chapter addresses the importance of social interaction in games as a medium to engage and motivate the players. The social interaction can happen in many forms, but here I only analyzed the effect of having a multiplayer game. The information gathered here is important because it is related to one of the research goals established for the development of this thesis, more concretely, the literature study contained in this section helps to find an answer for RQ 2.2.

6.1 Brief History of Multiplayer Games

Multiplayer games have been present since the creation of the first graphical interface video game, “Tennis for Two”, in 1958. The game was played on a single screen, an oscilloscope, and had each of the players controlling the game actions through a specialized controller [51]. A multiplayer game mode was of great importance in the success of the first influential video game in history, “Spacewar!” created in 1961. The game placed two players against each other and a winner and a loser was decided according to the game actions [22].

During the first generation of consoles there were different multiplayer games, but a game that catches the attention is Multi User Dungeon, which was played on a mainframe as an online game at the University of Essex, and it is considered the forefather of future multiplayer implementations.

During the 80s, other genres of games appeared that were presented as well as multiplayer modes. There are the examples of “Defender” a shooter game, and “Mario Bros” a platform game that presented the characteristic of multiplayer by alternating turns. This kind of multiplayer was popular for some decades.

During the third generation consoles time during the 90s, another genre was born which owns its origins to the ‘MUD’ games. Massive Multiplayer Online Games were created which presented the opportunity to play with other players in remote places in the world at the same time and in a same virtual world. These games continue to be highly popular in these years and present different sub-genres than the RPG which was the most popular at the beginnings of MMOs, but it still has “World of Warcraft”, an RPG, as its more

popular game [1]. Recently, due to the affordability of broadband connections, consoles also present the opportunity of playing games in a multiplayer mode without needing the players to be in the same location. They offer services as Xbox Live, Play Station Network and Nintendo Network.

6.2 Types of Multiplayer Games

Multiplayer games can be classified into networked or not networked games, depending in the conditions in which the players share the same virtual world. There is, however, another division of multiplayer games depending on how the players interact between each other in the game world, these can be described as follows [50].

Cooperative Multiplayer Games are characterized by having the multiple players aiming for a same objective. The players are faced against the game environment or against other players in the case that the game takes place in a team versus team situation. The good cooperation and sharing of resources becomes beneficial for completing a mission or beating a level in the game.

Semi-Cooperative Multiplayer Games presents players in the same team but with slightly different objectives that take place under a same big objective that is shared by all the players. In this kind of multiplayer game, the players compete for resources and could hinder the execution of the other teammates gaming.

Competitive Multiplayer Games are characterized by facing a player versus one or more players. This type of multiplayer game makes players compete for a certain resource, exterminate the resources of the opposite players or completing the level before the others do.

6.3 Attractiveness of Multiplayer Games

It is important to consider that both single player and multiplayer games should be innovative, playful and challenging in order to attract players and keep them using the game for a long time exposure [21]. Both kind of games are played because the players want to relax, entertain themselves, escape from the regular activities they do in their normal lives or simply, for getting some challenge in their spare time [15]. However, multiplayer games offer some characteristics that can attract players and retain them for a longer time in contrast with what could happen with single player games. Yee [66], for instance, studies the motivation for gamers to play online. There could be different reasons for playing online, nevertheless, those related with the social aspect provided by online games are concerned with socializing by playing and talking with other players that are sharing the virtual world. Socializing inside the game can take the players to form long time relationships with said people. And by socializing, the players obtain the opportunity to work as a team inside the game in order to accomplish a goal that otherwise would have been more difficult or impossible to obtain [66]. Players in cooperative games get satisfaction by maximizing not only the benefits for themselves but as well for the other players [61].

On the other hand, what other players look for in multiplayer games is competition which is not related to only playing against the computer [66]. Competitive games attract those players that are sure that their skills are developed enough to be able to beat other players and in the process this provides them a challenge that keeps them motivated in order to surpass others [61]. This competition aspect present in many multiplayer games can create an extra stimulation factor that could be used to keep players interested in playing the game in a long term because it provides them with an extra challenge that is always evolving [21]. In a competition environment, players usually seek to improve and achieve a high self-esteem state and it is especially motivating for persons with skills that are highly efficient [61].

Nevertheless, competition in a game can be enjoyable by weak and strong players because it can provide a more pleasant experience compared to the competitive environments to which the players are exposed in real life [19]. For instance, many players enjoy multiplayer games even if they lose due to the fact of being able to play with other players that could include friends, family or strangers. In online games, for example, some players enjoy that a network disadvantage can cause that weaker players can become the winners because it adds an element of challenge to high skilled players [15]. The competitive aspect in games transforms the playing experience and instead of becoming boring after the players have beaten the game, they could still be enjoyable because they would be competing in order to be best [21].

6.4 Relation to the Thesis

Having information about the nature of the social aspect of games is important because this thesis addresses the effects of multiplayer capabilities in motion based educational games. The literature regarding the types of multiplayer games is useful because it helps me in the design of the multiplayer modes in the game. Concretely, it provides guidelines to what a versus mode and a cooperation mode should address.

Moreover, the different ideas regarding the attractiveness of multiplayer games is important to this project because they provide me with a basis for comparing my findings, regarding the different game modes, during the game evaluation with real players.

Chapter 7

Games for Different Domains

This chapter aims to detect previous game concepts that address the area concerning their reusability for teaching in different domain areas. The information obtained during the literature studied is complemented with my experiences on designing a game that could be usable in different areas. The results of this literature study helps towards answering RQ3.1.

Usually games are built up with a certain genre behind them, they are either shooters, sports, RPGs, or others. A similar situation happens when talking about serious games. Games for education for instance are aimed to develop the skills of a student in a certain area of interest. Spelling games are aimed to teach kids to spell, math games are aimed for developing mathematical skills, and other very specific skills. However, there are some educational games that could be adapted to other domains. These games usually fall under the quiz genre and are aimed for the players to answer a question which could be made into a competition against other players.

7.1 Quiz Games

An example of a quiz game is Lecture Quiz by Wang et al. [62]. The Lecture Quiz game is developed as a multiplayer game where an unlimited amount of students can participate simultaneously. The game contains a series of questions and answers stored in a database that can be used as part of the game where the students are asked to answer a given question before a time limit runs out. The game gives feedback of the correct answer once all the players have submitted theirs or the time runs out. Even though this game was tested as in a Software Architecture class, the same game concept could be applied to other learning domains, since it provides with facilities to create other questions through a web-based MySQL interface.

A similar case is found in The School Quiz, a Buzz! based game developed in Britain and aimed for the education of kids that assist to primary school. The game takes input from the British curricula and covers all different domains that are being taught in British schools. The game allows teachers or other interested stakeholders to modify the questions and the quizzes in order to adapt them to their necessities [7].

7.2 Classification Games

The game developed in this project is similar in the aspect of being able to be adapted in different domains, the difference is that the game is specialized into classification of concepts in the area of interest. Currently, I was not able to find literature under classification games being applied in different domains. I demonstrate its applicability by providing a modifiable system that could be reused by swapping the objects used in the game and their metadata. The game is designed as a tool to teach recycling, but I created a small prototype for applying the same concept in a different learning area which is math and the game prototype was aimed to teach the mathematical classification for numbers, that is, real numbers, digits, imaginary numbers, among others.

7.3 Relation to the Thesis

As described previously, there are few examples of games that can be used in different domains. However, I try to approach the reusability of the game concept by creating a game in which classification of items is the main problem to resolve.

This chapter provides background information of games that try to address the reusability of game concepts, which is useful because it provides a framework to establish the domains in which the game I develop could be applied.

Chapter 8

Related Works

In this chapter I present some games that are related to some of the aspects in the research undertaken in this project. The games address education through the use of motion capture, or analyze the social aspect and multiple domain applicability of games. The games presented here contain important information that could be considered for the prototype I develop in this thesis. Nevertheless, the differences between these works and the one done by me are explained.

8.1 Movement-based Sports Video Games: Investigating Motivation and Game Experience

In this paper Pasch et al. [44] study the role of motion capture in the motivation and game experience of players of sports games. They formed a theory by analyzing the data obtained through interviews and questionnaires applied to participants using the game Wii Sports. The findings of the paper are important because they could be extrapolated to other kinds of games and not only sports. About motivation, the authors mention that the users feel eager to play because they want either to relax, where they tried to simulate the movements done in the game as they would in real life, and to achieve, where the movements performed were just “enough” to play the game efficiently. Regarding game experience the authors found that the players are subject to a more immersive experience by using a more natural interface as they would in real life, and in some cases they feel more related to the avatar they control because it performs the same movements as they do.

This project is related to mine because it studies the motivation and game experience in the game. The difference is that the study is based on off-the-shelf games and focuses on sports games because the researchers are interested in seeing games as media that does not promote sedentary gameplay.

8.2 Xdigit

Xdigit is a motion based educational game developed at Carnegie Mellon University by Lee et al. [31]. The game uses Kinect as the interaction mechanism between the players and the system. It uses a series of gestures that can be performed by the player who is situated in a spaceship and has to solve simple arithmetical problems in order to go forward in the game. Xdigit studies the suitability of motion capture devices, in this case Kinect, in educational games, and at the same time looking for a tool for improving mathematical skills in young children.

The project found that using motion capture for interaction in an educational game provides a degree of fun that attracts the players. Moreover, it also finds that the game is suitable as a teaching tool for learning mathematics at a young age.

The main difference with my project is that, while Xdigit tries to find out the suitability of motion capture in educational games, mine is interested in studying the effects of motion capture in the players, and as well consider other aspects not in the agenda of the Xdigit authors.

8.3 Lecture Quiz

Lecture Quiz is a mobile based game developed at NTNU by Wang et al. [62]. Lecture Quiz was designed to study the effects of games in higher education and is based on the popular game Buzz!. The game has a question and answer bank where the teacher deposits the answers to be asked to the students who have to respond before a time limit expires.

The game has two modes called Score Distribution and Last Man Standing. The first mode allows the participation of all the students at the same time and decides the winner at the end. Last Man Standing is similar to score distribution but in this mode only the players that have answered the question correctly go to the next round.

The game was tested for usability and usefulness, and presents interesting characteristics as being able to be played in different domains and can be used by different players at the same time. The former two characteristics are related to my project, but besides the fact that the game developed for the thesis uses motion capture, it also studies the effects of multiplayer capabilities on the participants and contrasts it with a single player mode.

8.4 Relation to the Thesis

The games described in this chapter address one or more of the research questions studied in this master's thesis. However, there are underlying differences that make this project unique and research worthy. These characteristics that make the game I develop different to the ones I mention in this chapter are present in the same section where each game is described.

Chapter 9

Developing a Motion Based Educational Game

This chapter presents information regarding the considerations that were made when developing the game. It includes points that must be taken into consideration in order to make the learning experience in the game a fun one and hence increase the success rate of the game with the players. It also includes information of the platform for which it was created and as well the motion capture device used to control the interaction between the players and the game. This chapter contains information that overlaps with the specialization project from which this master was conceived, so some of the following information is based in my previous work.

9.1 Designing a Fun Educational Game

One of the most difficult challenges when creating an educational game is the need to make it both fun and educational. Measuring the fun factor in a game is quite difficult because it depends on the subjective opinion of the players, however without this fun factor it would be hard to call the system being developed a game. The best available option is to study the target audience and create a game play that would cause a loss of time when the users play it [10].

As it was stated before, it is of high importance addressing the fun factor in the game. Malone proposes a series of heuristics in order to make a game fun. There are three categories that enhance the intrinsic motivation of the players during a game. This intrinsic motivation not only creates an enjoyable experience for the players but it promotes learning at the same time. The three categories can be classified as challenge, fantasy and curiosity [32].

Challenge is important because a game that is easily beaten or when the possible outcomes are known beforehand can create a boring experience for the player and would keep him from playing the game or not trying it again. A challenging experience in a game should include a goal that the player would seek himself by

putting into practice the skills needed for playing the game. The goal should be attained by making response to a series of uncertain outcomes from the game itself that could be presented in the form of different levels that could be adjusted to the players' current skill or by hiding important information that the player must seek.

Fantasy can provide the players the possibility of interacting with objects and environments that are not common or cannot be conceived in real life. Adding fantasy into a game can promote motivation and engagement in the players to try and keep playing the game.

Curiosity creates that the players seek to know what is going to happen in the game, and it keeps them playing and learning in order to find an answer. Adding curiosity to a game can be achieved in a cognitive level by hiding information or presenting it randomly, or by simply stimulating the players' sensory system as it could be with graphics, sounds or the way they interact with the game.

9.2 XNA Framework

XNA is a Microsoft initiative which main purpose is to provide a framework for game developers to be able to build games in an efficient manner [47].



Figure 9.1: The XNA Framework [2].

The XNA framework aims to ease the game cross-platform development. Games created with XNA are able to run on Windows based computers, Xbox 360 and Windows Phone, however some of the functionalities provided for the .Net Framework, which is used by XNA, are only available for the Windows and not to the other two systems [48]. An overview of Microsoft XNA can be seen in Figure 9.1.

9.2.1 XNA Framework

The XNA Framework can be seen as a series of layers that provides an abstraction for many of the issues presented in game development. These layers build upon each other to provide the developer with a framework for easy and quick game development. A brief description of each of the layers can be seen as follows. [11, 49].

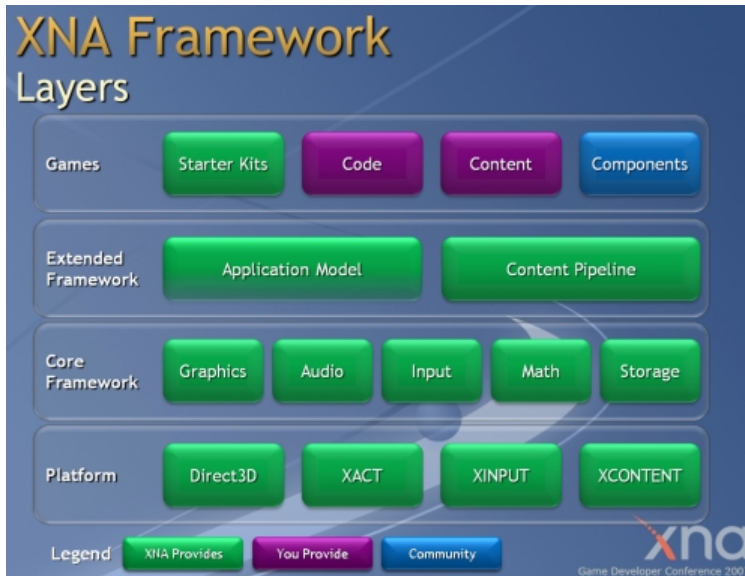


Figure 9.2: The Layers in the XNA Framework.

The Platform Layer is the lowest layer of the XNA Framework. It contains a series of libraries and provides an abstraction for the use of hardware related devices as video, audio and input mechanisms that could represent keyboards, mouse and controllers. It also provides an XML API, XContent, for the management of game assets [42].

The Core Framework Layer provides the developer with different libraries for the management and usage of graphics, audio and input mechanisms. The management of said resources is done during the game loop that is provided by the XNA framework as well. This layer also provides math utilities and storage libraries useful for games.

The Extended Framework Layer is further subdivided into the application model and the content pipeline. The application model provides libraries for easy manipulation of graphics, messages and sounds among others. The content pipeline is responsible for the addition of graphics, sounds and other game assets into the game being developed [41].

The Game Layer represents the code implemented by the developer for the development of the target game. It can include XNA specific code and can as well make use of

other projects.

9.3 Microsoft Kinect as Motion Capture Device

Microsoft Kinect is a motion capture device created by Microsoft and revealed as Project Natal in 2009. It is a system for controlling video games for the Xbox 360 in a hands-free fashion where no physical controller is present [57]. Referring to the classification of motion capture technologies, Kinect falls under optical based marker-less category where the user only needs to be in front of the device's camera in order to have his gestures captured. Microsoft's motion capture device is currently offered as a product for Xbox 360 and Windows based computers. The Windows based device is however more specialized offering a Near Mode for usage while sitting in front of a computer [35].

9.3.1 Kinect Features

The device has an RGB camera capable of capturing color images in a three data channel with a resolution of 1280x960. In order to capture the depth of the objects in the space, Kinect has an IR emitter which emits light and IR depth sensor which reads the light reflected by the objects being tracked. Kinect is also capable of capturing sound by using an array of microphones which can locate the source of the sound and its direction. Another hardware feature presented by the device is the possibility of changing its orientation in a three-axis manner by using an accelerometer [36].

The cameras present an angle vision of 57.5 degrees horizontally and 43.5 ± 27 degrees vertically, having the depth sensor being capable of capturing the depth of objects situated between 0.8m and 4m from the device. It is able to track up to two skeletons and detect up to six persons. Kinect is able to recognize and adjust to skeletons in a standing mode and sitting mode. Regarding the audio capabilities of the device, it is capable of noise cancellation and as default it tracks the loudest sound source [33]

9.3.2 Kinect SDK

Due to the popularity of Kinect within the enthusiast and research communities, Microsoft decided in 2011 to release a software development kit in order to address these communities desires and enhance the bonds of the company with them [28].

The Kinect SDK requires Visual Studio 2010 and the .NET Framework 4.0 in order to work, moreover it offers developers the possibility of using it with different programming languages as C++, C# and Visual Basic [64, 34]. With the release of the Kinect SDK using it with Windows based computers is possible in contrast to its beginnings when it was exclusive for the Xbox 360.

The SDK has libraries to get access and manipulate the raw data from the tracked skeletons. It also provides developers with the possibility of creating their own gestures to be used in their applications. The gestures are now not only exclusive to body parts but it also offers the opportunity to recognize facial gestures [36].

Microsoft is continuously updating the Kinect SDK. The newest version released in 2013 adds new features that would make applications development easier with their new 'push'

and 'grip' controls. More interesting is the Kinect Fusion that allows the construction of 3D models of objects captured by the Kinect device [37].

9.4 Relation to the Thesis

The information obtained in this chapter helps to develop an educational game that is fun and pedagogically useful at the same time.

Moreover, I describe the framework to be used for the game development. Knowing about the different parts that compose the underlying technology, in this case XNA, is important because it will give the basis to develop a game that exploits the framework and hence has more possibilities of becoming successful within the players.

I also described Microsoft's Kinect in this section because this is the motion capture technology to be used for controlling the interaction between the players and the game. The information obtained helps me to design a better game interaction and to know the capabilities and limitation of the device that should be considered in order to avoid problems while the game testing takes place.

Part III

Own Contribution

Chapter 10

Game Prototype

As part of the research process, it was necessary to build a game prototype in order to have a tool useful for answering the RQs. In this chapter I present important aspects of the game prototype developed during this thesis. In Section 10.1 a detailed description of the prototype is given in order to have a better understanding of the game used in the study. Afterwards, in Section 10.2 I mention the different requirements captured for the game prototype. The software architecture chosen by the game follows in Section 10.3. Finally, implementation details are given in Section 10.4.

10.1 Game Design

In this section I present the characteristics of the game being developed. It includes a description of the game elements such as graphics, sounds, characters, controls and some of the gameplay. The game presented here is a continuation of the prototype developed during the specialization project which I performed previous semester. The current design of the game includes elements of the last iteration, and changes and additions that were detected as areas of opportunity during the last evaluation of the game and through a brainstorm held with Cyberlab. In this section a summary of the work performed previously is presented for a better understanding, and afterwards the changes and additions are described.

10.1.1 Previous Prototype

Game Overview

The game was designed as a single player game where the players could take over a recycling plant and control the separation of the different wastes that came through a conveyor band. The game was designed with two play modes in mind. The players advanced through the levels in the game by either accumulating a certain amount of points or by completing a pre-established mission. The game was designed to map the recycling process done in Trondheim, Norway, but provide at the same time a configuration interface to be able to modify the game and have it adapted to the recycling needs in other cities.

The interaction of the players with the game is done by using motion capture with the Microsoft Kinect device and with Windows based computers as the target platform.

The Game Screens

The user interface in the previous game iteration was provided by a set of screens where the player was able to navigate through the use of menus or by the flow established in the game. The game screens that were designed previously are the following:

- **Main Menu Screen:** This is the first screen to be presented to the player. It includes options such as arcade mode, mission mode, scores and exit. The player is able to choose this by using the menu navigation actions.
- **Scores Screen:** The player arrives to this screen through the main menu. It shows the current top 10 scores in the game. The player can exit by performing the cancel action.
- **Gameplay Screen:** This screen was used for the arcade and mission mode. A detailed description can be found in the Arcade Mode Screen in Subsection 10.1.2.
- **Pause Screen:** The player arrives to this screen by performing the pause action during gameplay. It includes options to return to the game and exit the game which the player can use with the menu navigation actions.
- **Confirmation Screen:** This screen is shown when the game requires the confirmation for an action taken by the player. It is a Yes/No dialogue that can be used by the player with the accept or cancel actions.
- **Game Over Screen:** This screen appears when the player runs out of credits during gameplay. It has a timer and no further actions from the player are expected.
- **Save Score Screen:** It appears after the game over screen. It indicates the top 10 scores and expects the player to input his name. At the end the game shows the player's current ranking.

The concept screens used in the game developed for this thesis can be seen in Subsection 10.1.2.

User Interaction

The user interaction with the game was designed to be controlled through the use of gestures that can be detected by the Kinect device. The gestures were designed to be as natural as possible. They were used for controlling game elements such as the pistons and the bonus items, but they were also used for menu navigation purposes.

Some of the gestures were updated in order to provide an easier execution of them. They can be seen in more detail in Subsection 10.1.2.

Art in the Game

The art in the game was composed by different graphics used in the game. Most of them have been updated in the current iteration in order to provide a better graphical experience with smoother animations. Sounds were also included in the design of the game, however they were not implemented in the previous prototype.

The art elements of the present prototype can be seen in more detail in Subsection 10.1.2.

Gameplay

As mentioned earlier, the first game prototype was developed as a single player game. The gameplay was designed to have the following modes:

- **Arcade Mode:** The player separates as much wastes as possible before he runs out of credits. The difficulty of the game increases as the player score more points.
- **Mission Mode:** The player receives a recycling mission which he has to accomplish to advance to the next level.

10.1.2 Current Game Design

As explained in the beginning, the current game prototype builds upon the game developed during the specialization project. But it includes some changes and additions to its functionality. The game is now designed as a two player game, still including an option for single mode. The title is “The Recycle Game”, something that did not change from the previous iteration. It is meant to be played on Windows based computer, but it is designed to be easily played with the Xbox 360 as well.

Goals

The game prototype works as an instrument to achieve a different series of goals that are of interest for the various stakeholders involved. The goals can be separated into educational goals and research goals.

The educational goals are related to the capacity of the game to actually be able to help kids learning about waste separation while keeping them motivated with a fun gameplay. The research goals are associated with the RQs in this thesis, and can be read in Section 3.1.

User Interface

The user interface in this game is provided through the different screens presented in it. The elements of the screens are controlled by the players which perform some pre-defined actions. These are captured by the Kinect device, keyboard or control pad.

A description of the screens in the game is given in the following paragraphs.

Main Menu Screen The main menu screen presents more options than the prototype developed in the last iteration did. It includes now options to choose more play modes (cooperation and versus), and options, added to the already present arcade mode, scores

and exit. The option of mission mode was deleted in this iteration since it is not a part of the game anymore. The actions accepted in this screen are the menu navigation ones.

Scores Screen This screen remains the same as in the previous prototype. It shows the current top 10 scores in the game to the player. The only action available in this screen is the cancel action which is used to exit to the main menu.

Arcade Mode Screen This screen is similar to the Gameplay Screen present in the last iteration. It contains however a reorganization of the game session information such as the credits of the player, the current score and messages used in the game to indicate an achievement accomplished or a negative status.

The game elements present are the conveyor band in the center of the screen which presents an animation while it transports items. Both the band speed and the items being transported changes according to the score and actions performed by the player. The screen also contains the pistons at the sides of the band having maximum 6 of them (3 on each side). The pistons are controlled with the swipe actions. Bonus items also appear in this screen and are activated with the accept action.

The player can go to the pause menu by performing the pause action.

Cooperation Mode This screen is a replica of the Arcade Mode, it includes the same amount of elements and allowed actions. However, each player controls only the pistons on their side of the band.

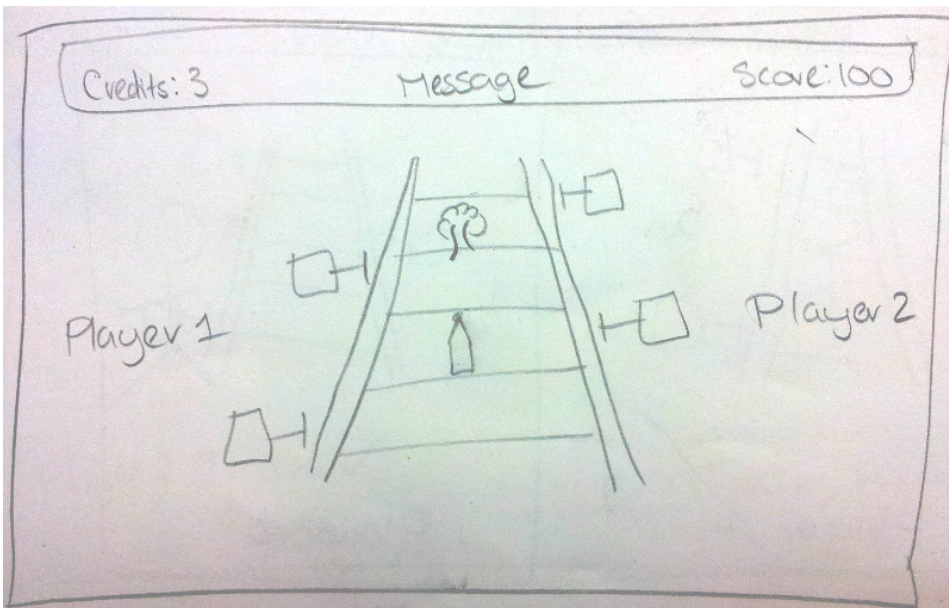


Figure 10.1: Cooperation/Arcade Mode draft concept.

Versus Mode The versus mode presents a screen divided vertically in half. Each half presents a similar layout as the single player mode, with the same elements and game session information. However, the actions taken by the opposite player can modify the position of the game elements and the messages received by the player.

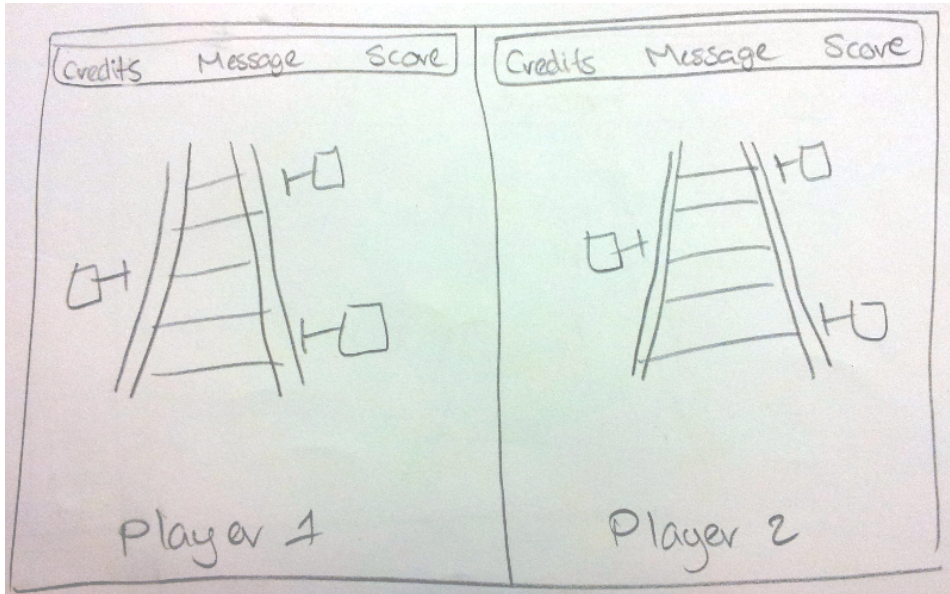


Figure 10.2: Versus Mode draft concept.

Waiting Screen This screen appears when the Kinect device is activated and at least one of the players stops being tracked by the device. The device shows the silhouette of the players and starts again once the device is able to track all the necessary players.

Pause Screen The screen appears when a player performs the pause action in the arcade, cooperation or versus mode. It is controlled by the player who paused the game and through the use of the navigation action they can select to either continue the game or exit it.

Confirmation Screen This screen asks for the confirmation of an action by a player. It usually appears when the player decides to quit the game. It is a dialogue screen where the player will either accept or cancel using the accept or cancel actions respectively.

Game Over Screen This screen has changed from the last iteration. It appears once one of the players runs out of credits and indicates that the game is over. It shows statistics regarding the game session, for the versus mode it shows the statistics of both players. The player exits this screen by performing the next action in the menu navigation actions.

Save Score Screen This screen has not changed from the last iteration. It contains the top 10 scores on the right side, and the alphabet on the left side which can be scrolled by the user in order to input the name to be saved on the data base. The scrolling is done with the menu navigation actions and the selection of a character is done by performing the select action in the menu navigation actions, the player indicates that the name is complete by using the accept action. Once the player saves the name the screen indicates the ranking of his score.

Game Interaction

The game still uses the same gestures as in the previous prototype implementation, however some of them were relaxed a bit more in order to make them easier to perform by the user. Moreover, the game provides as well the means to control the game elements and menus from the keyboard or control pad. The set of gestures, keyboard and control pad that can be used in the game are known as actions. The actions in the game can be separated in two groups: menu navigation and gameplay actions.

It is important to note that, even though the game can take inputs from a keyboard and a control pad, the gestures captured by the Kinect device always take priority, so if players are detected by the device the other two methods are ignored. The said gestures were designed having in mind that they would be easy to learn and perform, so the players can use with movements as natural as possible [33].

Menu Navigation Actions The actions performed in this action group are tailored towards the movement between the options in a menu screen. Each of the actions are described in terms of the keyboard, control pad or gestures used to control them.

Action	Gesture	Controller	Keyboard
Navigation	Move right arm up and down	Dpad	Arrow
Select	Swipe arm left to right	Start	Enter
Accept	Both arms above the head	Start/A	Space(P1) Enter(P2)
Cancel	Arms in 'X' position	Back/B	Escape
Pause	Join hands	Back	Escape

Table 10.1: Description of the Navigation Actions.

Gameplay Actions The gameplay actions are designed to control the pistons in the game through the swipe actions. The swipe actions are distributed according to the positions of the pistons around the band. There are up to six swipe actions that could occur in the game. During gameplay the bonus items are activated through the use of the Accept Action described in the Menu Navigation Actions.

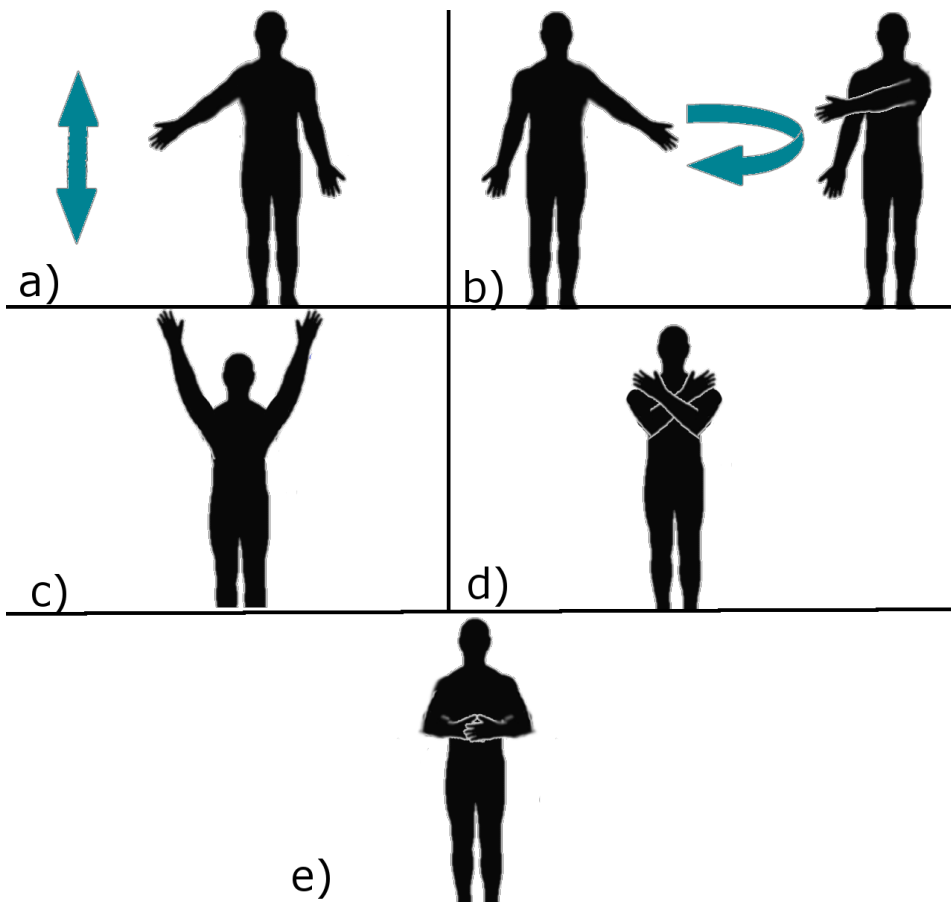


Figure 10.3: a)Navigation b)Select c)Accept d)Cancel e)Pause

Action	Gesture	Controller	Keyboard
High swipe left	Swipe right arm from right to left while above the head	Right Trigger	pad9(P1) E(P2)
High swipe right	Swipe left arm from left to right while above the head	Left Trigger	pad7(P1) Q(P2)
Swipe left	Swipe right arm from right to left while at chest height	Y	pad6(P1) D(P2)
Swipe right	Swipe left arm from left to right while at chest height	X	pad4(P1) A(P2)
Low swipe left	Swipe right arm from right to left while below waist	B	pad3(P1) C(P2)
Low swipe right	Swipe left arm from left to right while below waist	A	pad1(P1) Z(P2)

Table 10.2: Description of the Gameplay Actions.

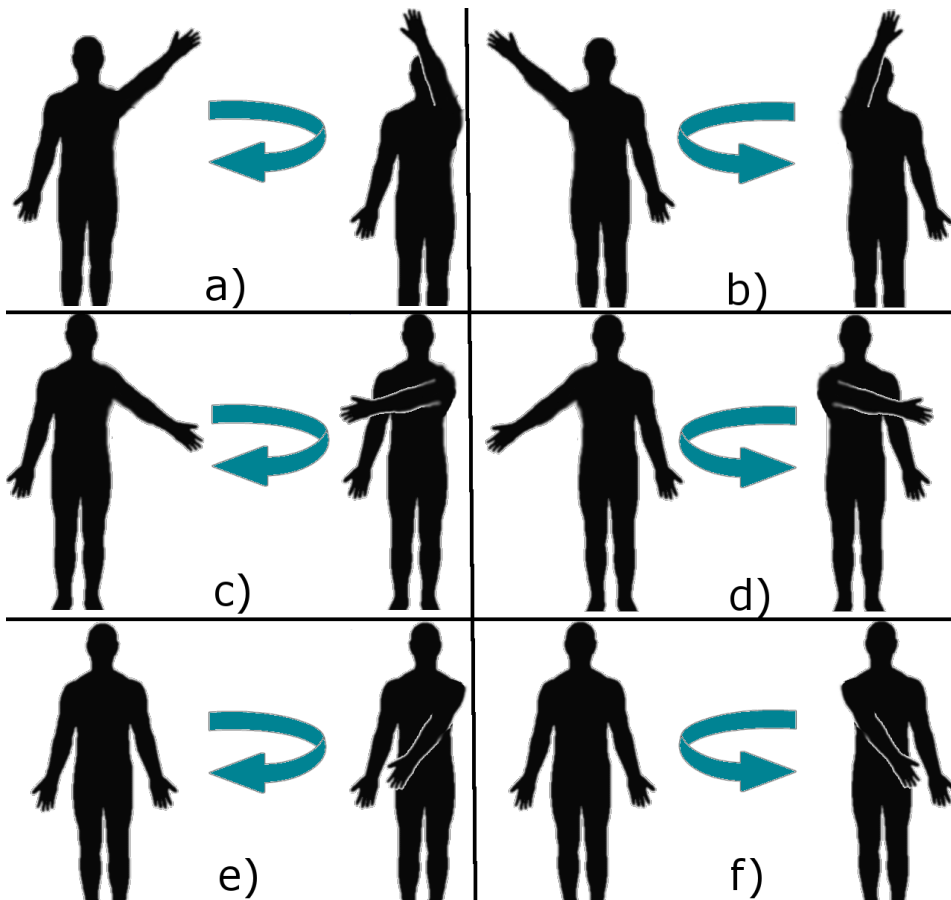


Figure 10.4: a)High swipe left b)High swipe right c)Swipe left d)Swipe right e)Low swipe left f)Low swipe right

Game Art

The art in the game is provided by the use of graphics and sounds that added with the use of gestures can stimulate the sensory system of the players and increase their curiosity towards the game [32].

Sounds The game plays a series of sounds as background music or as an acoustical affordance for the actions performed by the player. The sounds used in this prototype come from free sounds found on the internet that can be used for non-commercial purposes. The sounds are played in the following situations:

- Background music for menu screens.

- Background music for gameplay.
- Sound for item classified (recycled) correctly.
- Sound for item classified incorrectly.
- Sound for bonus item activated.
- Sound for game over.

Graphics The graphics are represented by the font used for the messages and the game elements present during gameplay. The game is presented as a 2.5D where all the elements are done with 2D textures but by using perspective and movement effects, a 3D effect can be achieved. The graphics used are very simple and they work as a placeholder that can be easily swapped.

- Font: A free use for non-commercial purposes font is used. The name of the font is Rabbit on the Moon. This font is used because it could be more attractive to the audience than other options.
- Conveyor Band: This game element has been revamped. It is now composed by a band texture and a series of band segments that increment in size horizontally while they travel on the band. This creates a better experience and smoother animations.
- Pistons: These elements have been revamped as well, and separated into two textures, the body and the bar. The bar is positioned behind the body and when the piston is activated it moves horizontally to the center of the conveyor band, creating this way a better animation effect. Each piston represents one of the possible recyclable items.
- Recyclable Items: These are items that represent products that can be separated during the recycling process. They are regular items used every day and in this prototype includes plastic, paper, glass, metal and other wastes in order to map it to the waste separation done in Trondheim, Norway.
- Bonus Items: These items represent extra actions that can take place in the game. They could be extra credits, double points for 15 seconds or slowing down the speed of the conveyor band. In the case of the versus mode two more bonus items are added, and when activated they affect the opponent, they are the swapping controls and randomize pistons bonus items.

Gameplay

The gameplay was designed having on mind the recommendations of Malone [32]. Challenge is presented by instance, by having different kind of items that the player has to recognize and react to their speed in order to recycle them. As well, by having a speed difficulty in the game that increases while the player increments his score. Moreover, there's a present challenge in the two player modes where the bonus items activated by the opponent can randomize the controls or the pistons of the player; or by the need to coordinate

both players actions as a team in the cooperation mode.

Curiosity, as explained earlier, is provided by the use of graphics, sounds and the Kinect that stimulate the sensory system of the player.

Fantasy is not very strong in this game because it only places the player as a worker in a recycling plant, however I think that the use of motion capture and the different challenges used in the game can compensate this aspect and hence make the game entertaining. The game modes in this game are described as follows.

Arcade Mode is a single player free for all mode in which the player tries to recycle correctly as many items as he can. New items are added for the player to recycle while he increments his score. Incrementing the score also affects the speed at which the items travel through the band increases creating a more challenging gameplay. The bonus items that appear in this mode are the extra credit, double points and slow down.

Cooperation Mode is a two player free for all mode where the players control each one half of the pistons on the side of their band. The players have to cooperate and only recycle the items they are responsible of. The game becomes more difficult by adding more items to recycle and incrementing their speed depending on the score of the player. Moreover, at certain points the pistons randomize so the players have to pay attention that the items they were responsible have changed after the piston swap. The bonus items that appear in this mode are the extra credit, double points and slow down.

Versus Mode is a two player versus mode where each player has his own conveyor band and set of items that he must recycle as fast as he can before running out of lives in order to beat to opponent. In this mode the difficulty increase is managed independently for each of the players in the same fashion as it occurs in the Arcade Mode with the addition of items and the speed of them according to the score of the player. The bonus items that appear in this mode are the extra credit, double points and slow down. It presents as well the swap controls bonus item that when activated mirrors the control of the opponent's pistons for some seconds, creating in this way an advantage for the player. In this mode the randomize pistons bonus item appears as well that, when activated, swaps the place of the opponent's pistons permanently giving the player an edge to be the winner.

10.2 Game Requirements

This chapter describes the requirements found for the development of the game prototype. The requirements describe the functionality that the game prototype has to provide, and restrictions dictated by the technology and quality attributes desired by Cyberlab to be taken into consideration for the game development. The requirements are inherited from the previous prototype and are still present in this prototype, they can be seen in Appendix C.

10.2.1 Scope

The present project is a game prototype to be used as part of the research taken during the master's thesis of the Information Systems program at NTNU. The prototype is being developed by one person and it is a continuation of the work I performed during the course TDT4501 Specialization Project as part of the study program. As it happened in the previous prototype developed, the game makes use of code used by Microsoft for screen management, and the code developed by Cyberlab to manage the database and gestures. This decision was taken because those were some of the requirements established by Cyberlab since the conception of the game. The final prototype to be developed must be complete enough to be tested with potential players.

10.2.2 Requirements

The game prototype acquired new requirement that needed to work alongside the requirements established in the last prototype developed. For this reason some of the requirements captured previously disappeared and others took their place. The functionality added is separated according to the place where it is involved.

General Characteristics

In addition to the requirements detected in the first prototype (see Appendix C.2), the following functionality has been added in the game.

ID	Name	Description	Priority
GC03	Localization	The game shall provide localization so it can be presented in English and Norwegian.	M
GC04	Calibration	The game shall calibrate the Kinect device to capture the skeleton of the player.	L
GC05	Sounds	The game shall have music background and sound for the game elements when these are activated.	H

Table 10.3: General characteristics requirements.

Gameplay

In essence the same requirements applied to all the modes but in cooperation mode and versus mode some modifications and additions need to be done.

Arcade Mode This mode includes all the functionality listed previously under the GP code (see Appendix C.5). The following requirements were added.

ID	Name	Description	Priority
GP17	Add Items	The game shall introduce more variations of the items when the player scores 30 and 120 points.	M

Table 10.4: Arcade Mode requirements.

Cooperation Mode Cooperation mode includes all the functionality listed under the code GP (see Appendix C.5) in the previous iteration. It adds as well the requirement GP17, seen in Table 10.4, specified in the Arcade Mode. It contains as well the following requirements.

ID	Name	Description	Priority
GP18	Randomize Pistons	The game shall randomize the pistons every 250 points.	H
GP19	Piston's Control	The game shall ensure that the players only control the pistons in their side of the band.	H
GP20	Control Swap	The game shall swap the control of the pistons every 150 points.	M

Table 10.5: Cooperation Mode requirements.

Versus Mode The versus mode includes all the functionality included in the GP code (see Appendix C.5), however this functionality is allocated to each of the players. For instance, GP02 indicates that there will be two conveyor bands, each at the center of the players' side of the screen. This mode also includes the requirement GP17 specified in the arcade mode and GP18. It also has the following requirements.

ID	Name	Description	Priority
GP21	Enemy Control Swap	The game shall mirror the controls of the enemy pistons for 10 seconds when the control swap bonus item is activated.	H
GP22	Enemy Piston Randomize	The game shall randomize the the enemy's pistons when the player activates the randomize pistons bonus item.	H

Table 10.6: Versus Mode requirements.

Game Over Screen

The functionality provided by the first prototype was completely erased. The new functionality is described in the following requirements.

ID	Name	Description	Priority
GO01	Statistics	The game over screen shall indicate the player and the amount of items recycled per type and those missed.	L
GO02	Exit Screen	The game over screen shall exit with the Select action.	M

Table 10.7: Game over screen requirements.

Options Screen

The options screen contains a set of predefined options that the player can adjust to improve the game experience.

ID	Name	Description	Priority
OS01	Sounds	The options screen shall have an option to turn off the sounds.	L
OS02	Language	The options screen shall have an option to change language.	L
OS03	Navigation	The options screen shall be navigated with the navigation actions.	M

Table 10.8: Options screen requirements.

Waiting Screen

This screen only appears when the game is using Kinect and one of the players cannot be tracked. The functionality is described as follows.

ID	Name	Description	Priority
WS01	Silhouettes	The waiting screen shall show the silhouettes of the players that Kinect is tracking.	M
WS02	Exit Screen	The waiting screen shall exit and continue gameplay once the player or players have been tracked for 5 seconds.	M

Table 10.9: Waiting screen requirements.

Instructions Screen

This screen appears in the main menu and gives the users information about how to play the game.

ID	Name	Description	Priority
IS01	Instructions	The instructions screen shall describe the game elements and how to operate them.	L
IS02	Navigation	The instructions screen shall be navigated using the navigation actions.	L

Table 10.10: Instructions screen requirements.

Other Screens

The rest of the screens conserve the functionality that was implemented during the first prototype. So no further functionality requirements are detected.

Non-Functional Requirements

The game conserves the same non-functional requirements that were taken in consideration during the development of the first prototype.

10.3 Game Architecture

This section describes the software architecture chosen for this project. The changes in the requirements in comparison with the first prototype provoked a change in the architecture for the second prototype, however since the first architecture was developed with high modularity the changes were not too severe. In the present section I describe the most important architectural drivers and stakeholders concerns in order to establish what is to be address in the architecture besides the functionality. Afterwards I present briefly the architectural patterns and tactics used. Finally, the software architecture is presented using the 4+1 views suggested by Kruchten [30] because they address as many stakeholders as possible.

It is important to note that the architectural drivers, the tactics and patterns used have not changed since the implementation of this first prototype, hence these overlap with the current project.

10.3.1 Game Architecture's Goal

In order to have a goal in mind when designing the architecture, it is important to identify the different stakeholders and their concerns.

- Developer: Interested in designing an architecture that addresses the main quality attributes and at the same time having a design that can be implemented and tested with a short deadline.
- Cyberlab: Interested in having a game prototype that can be played by the target audience and which is easy to read and modify in the future.
- Players: Concerned with having a game that is fun to play and which does not need a huge amount of time to learn and use.

- Educator: They are interested in a game that is educational but at the same time fun to play in order to keep the players motivated and engaged.

According to the information analyzed from the concerns of the stakeholders, I concluded that the most important quality attributes to be address with the software architecture were the modifiability and usability. The considerations taken for these attributes can be seen in Subsection 10.3.2. This decision was taken because the main goals of the game prototype as a product are that it is easy to use and understand in order to attract as many players as possible. Moreover, Cyberlab desires to have a game that can be easily modified to evolve it into a final product, and adapt it to different learning domains.

For the architectural design, it is also important to have in mind some architectural drivers such as the limited budget. The prototype shall be developed in twenty weeks at the same time the research is performed. Moreover, I participate as the only developer who has little experience with XNA the development. In addition, I will have to take into consideration different designs in order to develop a game which is able to reflect all the fun and educational characteristics that have been established.

10.3.2 Patterns and Tactics

As mentioned before the most important attributes that the architecture has to address are modifiability and usability. In order to address these I use the Model-View-Controller (MVC) architectural pattern because it offers advantages for addressing modifiability. For instance it would allow a separation of concerns by separating the objects, their logic and representation which in turn eases the modification for future prototype iterations. At the same time this separation of concerns will allow for a better code re-usability which is attractive for Cyberlab.

Perhaps other patterns could be used, however, due to many of the constraints already imposed as reusing code from Cyberlab, Microsoft and even the code from the previous prototype, this was a difficult task. In addition, I consider that MVC addresses with high efficiency the modifiability desired for the game. Usability, which has been also detected as a quality attribute important in this development, is supported to a certain degree through the separation of concerns.

Other techniques I use for addressing modifiability and usability are expressed in the form or architectural tactics as suggested by Bass et al. [5].

- Modifiability: I address this by localizing the changes, that is, designing the modules of the game as independent as possible in order to only touch one module when it needs to be changed. In addition, I prevent ripple effects by hiding the information in the modules and isolate the repercussions to only those modules. Finally, I also provide a configuration file where many of the game elements can be modified and in this way I defer the binding time.
- Usability: As mentioned before, I address the usability with the design-time tactic that is provided by the separation of concerns in the MVC pattern. Furthermore, during run-time I make sure that the model of the user is kept by ensuring that the interaction with the game can be achieved by a regular person.

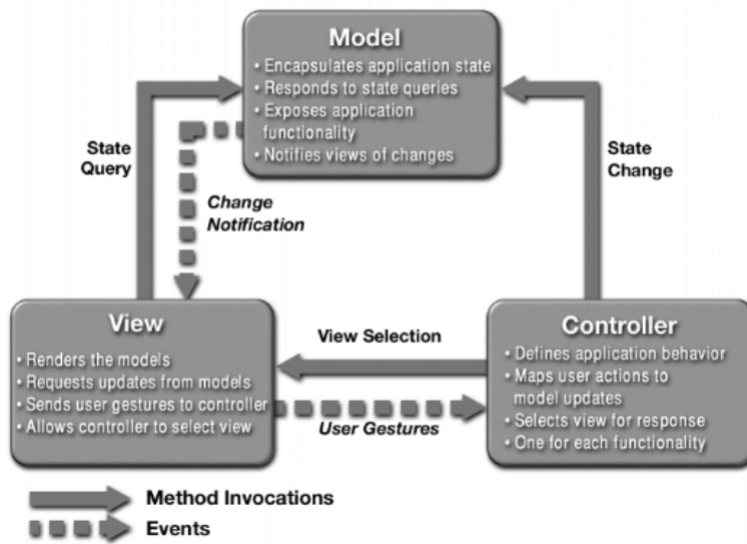


Figure 10.5: MVC description.

10.3.3 Game's Architectural Views

In order to communicate the software architecture with as many stakeholders as possible I decided to use Kruchten 4+1 views [30] aided with the use of UML diagrams. The architecture used in this prototype builds upon the architecture designed for the first prototype, however there are several changes and additions that needed to take place due to the new functionality added to the game.

Logic View

With the use of this view I describe the functionality of the system, which was described previously in the requirements listed in Section 10.2. Since some of the diagrams are too extensive, I present here a simpler version with only the most interesting modules. A complete version of the diagrams can be seen in Appendix D.

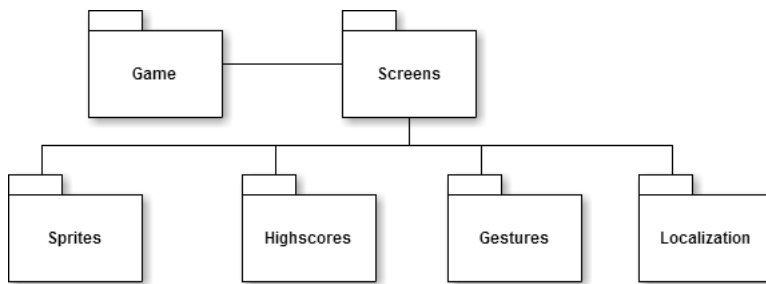


Figure 10.6: Subsystems composing the game.

The logic view is separated into subsystems for better understanding.

Game Subsystem This subsystem is in charge of the initialization of different variables that are necessary for the game. The most important characteristics are described as follows, the complete diagram can be seen in Appendix D.2.1.

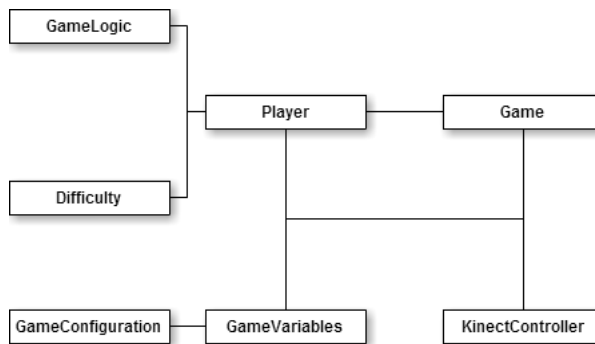


Figure 10.7: Simple version of the game subsystem.

- The KinectController module is responsible of starting the Kinect device. It is designed as a singleton class because having many instances of it would create performance problems due to the amount of resources that the device consumes and the amount of time it takes to start and stop the device.
- The GameConfiguration module is responsible of loading all the game elements specified to run in the game in the corresponding language. This configuration is used in all the parts of the application, hence it is contained in the GameVariables module, a singleton class which encapsulates other important variables to be used in the game sessions.
- Most of the game logic takes place with the combination of the Player, GameLogic and Difficulty modules. They establish the players in the game and the actions to be taken inside the game that modify the game elements that are part of the Player

instance. Having the game elements being part of the player eases the addition of different players in the game in contrast as being part of a screen.

Screens Subsystem The screens subsystem contains all the different screens used in the game. As mentioned earlier they are controlled by the Screen Management code supplied by Microsoft. Of the screens that represent the different parts in the game, the most important characteristics are the following. The complete diagram can be seen in Appendix D.2.2.

- The KinectScreen is a module that inherits from the GameScreen module developed by Microsoft. The main characteristic on this screen is that it contains important fields for receiving input from the Kinect device and gestures recognized by the Gestures Subsystem. Since all the screens of the game have the possibility of using Kinect, all of them inherit from this module directly or indirectly.
- The game mode screens (ArcadeModeScreen, CooperationModeScreen, Versus-ModeScreen) contain different variables needed for gameplay such as players, timers, messages and specific actions that can take place during gameplay such as pause or the activation of a bonus item. The main difference between these screens is the amount of players they manage and the interaction between them. They override the game loop in order to have a specific set of logic actions that need to take place.
- The game manages different kind of menu screens such as the options menu, pause menu, save score screen and the main menu, which inherit from the MenuScreen module that in turn inherits from the KinectScreen module. The reason behind this inheritance is the way in which the player interacts with these screens is different than in gameplay. The navigation actions are predominant over other kind of actions.
- Screens as the GameOverScreen, MessageBoxScreen, ScoresScreen and Waiting-ForPlayersScreen inherit from the KinectScreen module. However, they have a more informational or dialogue nature which reduces their interaction with the player to single commands in order to exit them.

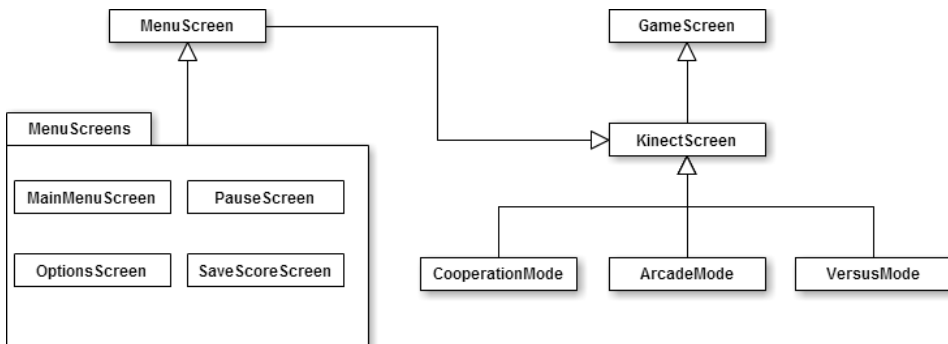


Figure 10.8: Simple version of the screens subsystem.

Sprites Subsystem The sprites subsystem contains all the visual game elements that are required for gameplay.

They contain the definition of the object and a controller for each of them in order to keep the separation of concerns proper of the MVC pattern. All of the game element models or their visual parts inherit from the Sprite module which has important information regarding the scale, position, texture and even an animation in case it is wanted. The diagram can be seen in Appendix D.2.3.

Gestures Subsystem This subsystem is in charge of declaring and recognizing the gestures performed by the players. It builds upon the gesture recognition code made by Cyberlab. The main contribution here is the creation of the specific gestures used in the game. The diagram can be seen in Appendix D.2.4.

High Scores Subsystem This subsystem (see Appendix D.2.5) was created by Cyberlab but was modified by me in order to adapt it to the game. It is in charge of saving and retrieving the scores of the players by communicating to the database through a set of PHP files. They parse and encode the information regarding the players and their scores.

Localization Subsystem This small subsystem was created in order to localize the game. It only contains two small modules that are in charge of using and selecting the correct string resource file according to the language wanted. The rest of the localization, such as game elements happens in the configuration files. The diagram can be seen in appendix D.2.6.

Process View

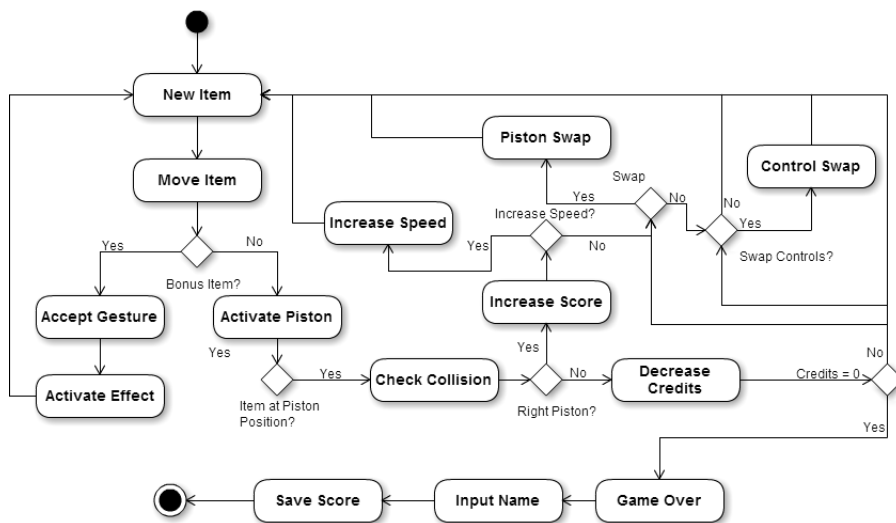


Figure 10.9: Flow during gameplay.

The process view can be seen in Figure 10.9. The process depicted there can describe the behavior of any of the three game modes available in the game. Those events that do not happen in a certain mode simply are skipped over by the logical flow of the game loop. This diagram is useful to detect possible performance problems that could occur due to a high demand of resources.

Development View

Even though the project was developed only by me, a development view with all the modules is useful to show the separation of the system. The modules are separated according to their function and degree of independence towards the game. For instance the game logic is the most domain-dependent because it is tightly coupled with the game concept, while modules such as localization and high scores manipulation can be reused in other projects with no modifications done to them.

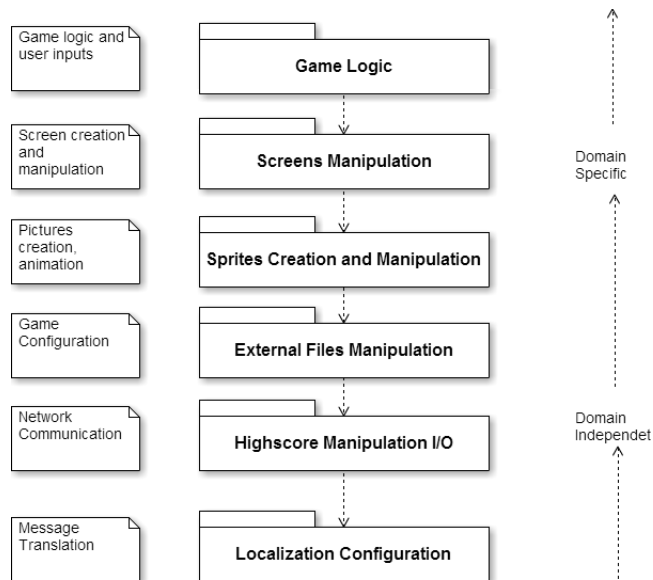


Figure 10.10: Development View.

Physical View

Most of the necessary resources for the game exist in a single host where the different subsystems described previously can be found. However the game has a common database for all its instances, hence an external database, to which the system communicates through the high scores subsystem. This external device can be considered part of the system.

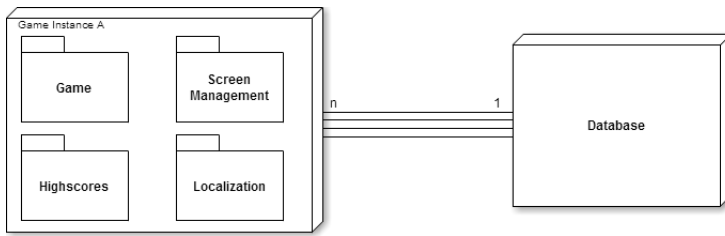


Figure 10.11: Physical View.

Scenarios

Through the use of scenarios, the main functionality of the game and its main actors can be seen. While the player actor can perform different actions related to the visualization of the screens their navigation and the actual playing in the game, the game actor reacts to these actions and gives an appropriate response to them. The use of this view is useful to communicate the game idea to all the different stakeholders.

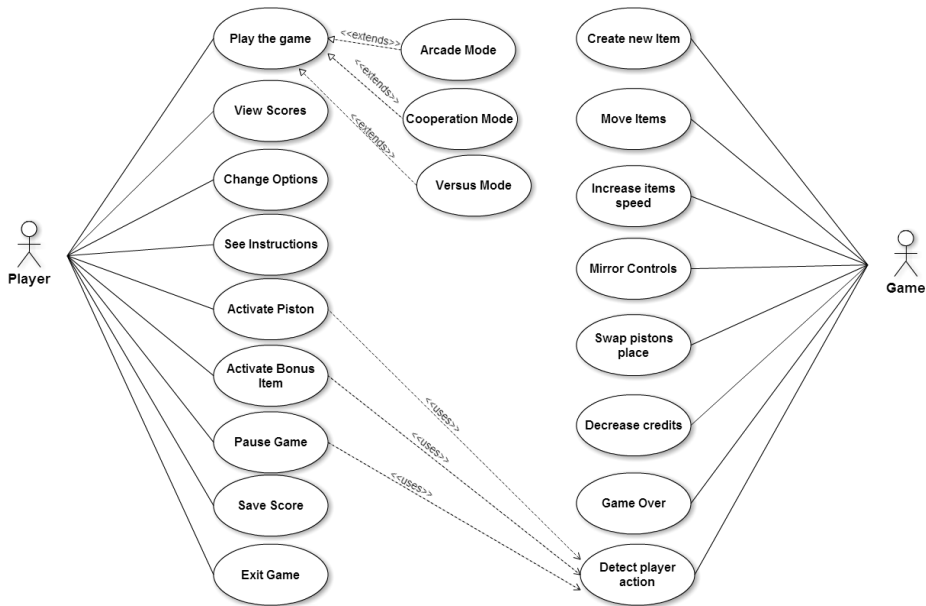


Figure 10.12: The different scenarios in the game.

10.3.4 Game Architecture Conclusion

Through the use of this architecture I am not only able to address the functionality needed for the game but as well the most important quality attributes required by Cyberlab and

the game itself.

The architectural design for this prototype is an evolution of the previous prototype's architecture, and it includes a new subsystem (Localization), as well as new functionality which is translated into the new game modes available in the game.

Thanks to the MVC pattern and the modifiability tactics used the game can be modified in future iterations easily. It is interesting to note that by applying the defer binding time tactic, the game is able to be adapted for a different domain by adding the needed resources into the content pipeline of the game and declaring the needed changes in the XML configuration file provided.

Having usability in mind was important to take into consideration when the game gestures used for the different input actions. The gestures are designed in a way that feels natural for the user with a visual affordance provided by the game. Moreover, I separated the various concepts in the game in different screens in order to provide a semantic and logical layout for the users.

10.4 Game Implementation

In this section I describe how the game "The Recycle Game" was developed for the present thesis. In other words it only describes the process taken for the implementation of the prototype and other issues such as the literature review and research undertaken are not discussed here.

10.4.1 Implementation Scope

The implementation of a motion based educational game was of high importance for this project since it would be one of the tools for performing the research necessary to answer the RQs that are described in Section 3.1. The game prototype developed as part of this master's thesis builds upon the previously developed prototype implemented by me a few months before. The present iteration solves some of the problems and unfinished work left and increments the capabilities of the product.

The implementation performed during this project and the resulting prototype is not by any means a finished product that could be released to the public, however it should be complete enough to be tested with the target audience. This means that most of the game functionality is implemented under the pre-established constraints, however details such as graphics, sounds among others that could give the prototype a more finished product appearance still need to be worked on.

Finally, it is expected that the prototype is of high quality to ensure that it could be picked up by Cyberlab by the end of this project and be able to continue working with it.

10.4.2 Implementation Overview

I decided to use an incremental and iterative development methodology because it gave good results during the development of the first prototype. However, before starting I actually considered other methodologies such as waterfall and scrum.

- Waterfall did not meet my expectation because it is a very rigid methodology where one part of the life cycle has to be finished in order to start the next one. This was not desired because I had to evaluate my ideas with Cyberlab, implement and test them and verify with the organization that it was something desired for the game.
- Scrum was a strong candidate but, due to the small developing team, I would not make a good use of the benefits of this methodology such as daily meetings and division of activities. However, the constant communication with the customer and the division of tasks into smaller ones was still very attractive.

The methodology chosen was an iterative process development inspired by scrum and waterfall. It consists in a series of phases that are in turn mini-waterfall cycles in which I still conserve the freedom to go back and make adjustments to the requirements and architecture and at the same time I am able to have constant communication with Cyberlab in which I can show them the functionality implemented in the prototype that keeps growing while more phases take place. A depiction of this methodology can be seen in Figure 10.13.

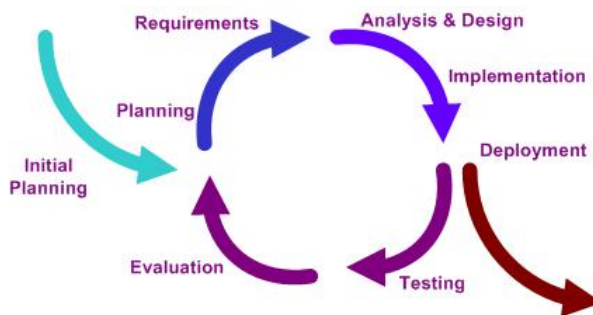


Figure 10.13: The development methodology followed for this prototype.

As indicated in the non-functional requirements, the game was developed using C# and the XNA Framework with the aid of code already developed by Microsoft and Cyberlab. In Table 10.11 there can be seen the total amount of lines that were used to develop this prototype. The count of lines of code does not include comments or code that was used for testing the application. These lines are mapped to the subsystems that can be seen in Figure 10.14.

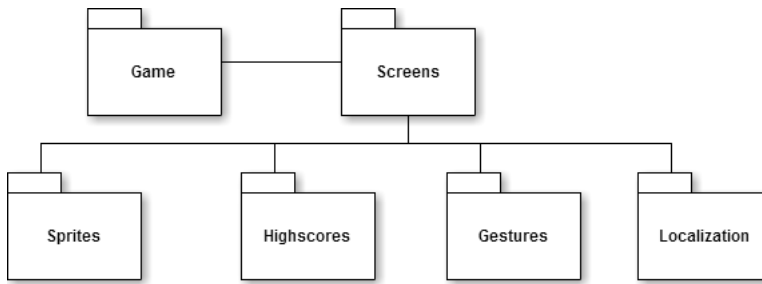


Figure 10.14: Implemented subsystems overview.

In comparison with the previous prototype, this iteration required the creation of different game elements such as textures. Some of the textures are however reused from the previous implementation. Sounds, on the other hand, were, as mentioned, obtained through the use of a free license for projects with no commercial purposes.

Subsystem	Lines of Code
Game	1183
Screens	2452
Sprites	2125
High Scores	146
Gestures	502
Localization	60

Table 10.11: Lines of code implemented in the prototype.

10.4.3 Implementation Phases

As mentioned before, the implementation was performed during a set of phases that built upon each other in order to implement the final prototype. This section describes the most important aspects and experiences during each of these phases that took place during the game development.

Phase One: Redesign Game Elements

In this phase the main goal was the redesign of some of the game elements in the game. This was done due the feedback got from testing participants of the previous prototype and the recommendations gotten from Cyberlab about having better graphic elements with better and smoother animations.

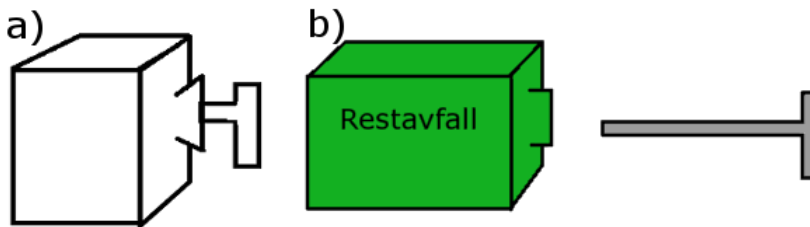


Figure 10.15: a) First Prototype: Pistons were a single texture. B)Current Prototype: The pistons are composed of two parts.

The elements that were found to fall under this category were the pistons, the conveyor band, and the item containers. The solution for this was separating each element into sub-elements in order to perform the animations in only those parts that required movement. With this it was possible to have a better control of the apparent speed of the conveyor band, and the movement of the pistons. An example of this design can be seen in Figure 10.15 in which it can be seen the contrast of the design of the piston in the first prototype and the current prototype.

Moreover, new functionality had to be added to the Arcade Mode in order to add more diversity of items that could be recycled, hence presenting an extra challenge and at the same time, communicate to the players that the different recycling wastes can be presented in many forms.

A problem detected in this phase was that the item containers were too unrealistic because the items seemed to go over them and suddenly disappear. I decided to manage the containers in a fashion similar to the pistons and decompose them in two parts, the back and the front part of the container and made sure that during the animation of the items going through them, the back part was always behind the item and the front part over the item.

Phase Two: Messages, Localization and Sounds

The work performed in this phase of the development aimed for a better presentation of the session information and gameplay messages. Moreover, it was decided as well to include the game statistics at the end of each session in the game over screen. It was as well decided that the introduction of sounds into the game should take place in order to present a more attractive game to the players.

In this phase I also discussed with Cyberlab the need to have the game in Norwegian because it would be tested with young kids who could feel more comfortable with a game interface presented in their own language. The decision taken was to introduce localization into the game instead of just performing a translation of the game. This was done through the implementation of the Localization Subsystem and the modification of the configuration file, which this time would include a file for each desired language.

The most important experience in this phase for me was the localization of the game. It took a few hours to find all the strings in the game and put every one of them in a resource file. This is the most effective approach of managing strings and I would recommend doing

this in future systems development.

Phase Three: From a Single to a Multiplayer Game

After discussing with Cyberlab the possibilities of making a game more engaging and motivating, it was decided that it would fit to have a two player mode in the game. The first multiplayer game mode to be introduced was the cooperation mode in which the game would present a screen similar to the Arcade Mode but it would allow the input from two different players.

The decision of having a second player in the game caused that some aspects of the architecture and design had to be modified. For instance the KinectController module had to be able to detect the second player and decide that the player on the left would be the first player. Moreover, it was necessary to give each piston a controlling player in order to avoid having both players controlling all of them.

The main problem detected in this phase was that it was quite difficult to figure out which of the persons detected were the ones being tracked as players by the device. In order for this I had to refer to documentation of the Kinect SDK in order to realize that the players closest to the camera were the ones being tracked. Moreover, I had to analyze the code in a white box fashion in order to ensure that player one was always the player closest to the camera and on the left.

```
1 foreach (Skeleton skel in skeletonData)
2     if (skel.TrackingState == Tracked)
3         skeletons.Add(skel);
4 if (skeletons.Count == 1)
5     skelPlayer1 = skeletons[0];
6 else if (skeletons.Count > 1){
7     if (skeletons[0].Joints[HipCenter].Position.X <
8         skeletons[1].Joints[HipCenter].Position.X &&
9         skelPlayer1 != null && skelPlayer2 != null){
10        skelPlayer1 = skeletons[0];
11        skelPlayer2 = skeletons[1];
12    }
13    else{
14        skelPlayer1 = skeletons[1];
15        skelPlayer2 = skeletons[0];
16    }
17 }
```

The main experiences here were related to developing game concepts that would make the cooperation mode more entertaining and not just a copy of the Arcade Mode but with two players. The decisions taken were the introduction of the randomize pistons and swap control concepts that would require the players to have better communication and react to the changes in the game.

Phase Four: Redesigning the Game Logic

This phase consisted in introducing a new game mode into the game, the Versus Mode. This is a two player mode that requires having two sets of independent game elements that

would change according to the actions of the player controlling them. The main challenge here was redesigning the architecture and transferring the ownership of gameplay elements from the screen to a player. This change created that the Player module became bigger and the screens smaller, it also made easier the management of the game logic by avoiding doing additional checks for deciding which player was the owner of a certain game element.

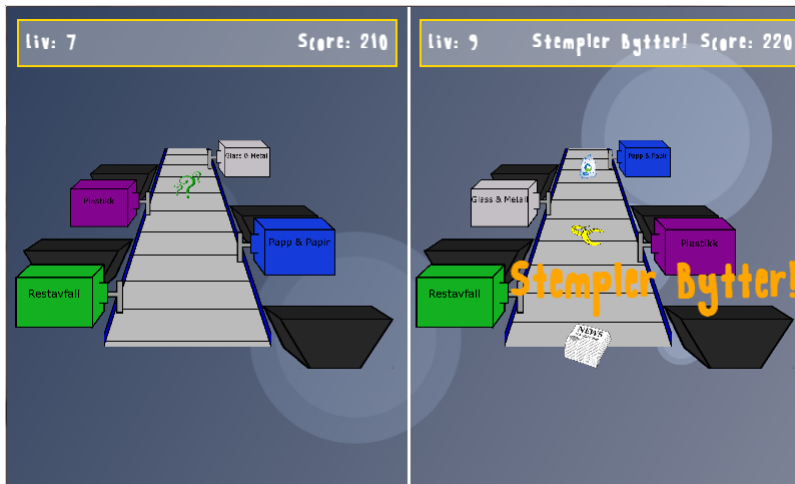


Figure 10.16: Gameplay during a Versus Mode session.

Due to the introduction of a second set of elements in the screen I also designed a series of methods imbued into the game elements controllers that would re-scale and re-position the elements in the screen.

Experiences left by this phase were that thanks to an iterative methodology it was possible to undertake such a big redesign that would have had bigger repercussions in a more rigid methodology such as waterfall.

Phase Five: Building a more Robust Kinect Interaction

The work performed in this phase was not too extensive but it was quite important in order to provide a better game experience. The work consisted in designing a game screen that would appear when Kinect was being used and at least one of the players in the game stopped being tracked by the Kinect device. The solution was the `WaitingForPlayersScreen` which pauses the game and only restarts once the player or players are being tracked again correctly.

The experience in this phase is related to circumstances that were not thought of beforehand. In this case I detected the need for such a screen when I was testing the application and observed that the game crashed when one of the players went out of the range of vision of the Kinect device.

10.4.4 Requirements not Implemented

There are actually few requirements that were not implemented in this prototype. However, this omitted functionality would be required and highly desired in a final product. The requirements which were not implemented deal with information that could be useful for the player which would have been present in the Instructions Screen, for the testing performed with the real players, since this screen is not available, a small demonstration is given to them.

ID	Name	Description	Priority
IS01	Instructions	The instructions screen shall describe the game elements and how to operate them.	L
IS02	Navigation	The instructions screen shall be navigated using the navigation actions.	L
GC04	Calibration	The game shall calibrate the Kinect device to capture the skeleton of the player.	L

Table 10.12: List of requirements that were not implemented.

Another aspect that was not implemented is related to usability of the application. The game does not perform any calibration of the Kinect device, hence it is necessary to set the device in a place that is certain to be able to track the players. A list of the requirements not implemented can be seen in Table 10.12.

10.4.5 Quality Assurance

The testing performed for this prototype was done at the end of each phase. I designed a series of requirements based tests to be executed in a black box manner to ensure that the functionality implemented was actually there and it worked correctly. The tests included only those requirements that were being implemented in each phase, however when new functionality was added and it had in common modules that were implemented in other phases, the tests from those previous phases were executed again. Table 10.13 has some examples of tests performed.

ID	Input	Exp. Output	Output	Pass?
GC05	None	Background song plays.	Background song plays.	Yes
GP18	Score + 250.	Piston should swap.	Pistons swapped.	Yes
GC03	Change language.	Game strings change language	Main Menu and Options screens remained the same.	No
GP10	Activate bonus item.	The bonus item disappears and its effect takes place.	The bonus item disappeared and the effect took place.	Yes

Table 10.13: List of some tests performed.

Testing the prototype in each of the different phases lead to the testing efforts at the end of the prototype were easier to perform and would only ensure that the system as whole was performing correctly.

The system test was performed as black box testing, and it was based on the requirements. So it was performed by testing again each of the requirements implemented during the development phases plus those requirements that remained from the previous prototype. The test excluded those requirements that were not implemented and which can be seen in Table 10.12.

Once the game went through and cleared the system test I considered it good to tested with real audience. The experiences obtained during the testing of the game can be better appreciated in Chapter 11.

Chapter 11

Results

In this chapter I present the results obtained in the game evaluation which was performed with the target audience. It contains information regarding the context in which the test took place, and the data obtained through the use of the questionnaires, interviews and observation.

11.1 Context

This section describes the situation in which the developed game prototype for this master's thesis was evaluated. It includes a description of the participants, the place in which the game was tested and the manner in which the interaction took place. The game evaluation took place on the 24th of May 2013 from 9.00 to 15.30 hrs.

11.1.1 The Research Group

The research group was composed of two participants that were related to the project.

- José de Jesús Luis González Ibáñez: I take the role of explaining the game mechanics to the participants and as well making the sure the correct performance of the game and resolve different technical difficulties that could take place.
- Alf Inge Wang: As my supervisor, he helped me getting in contact with the school, explaining the questionnaires and interviewing some of the students. This was done because Norwegian is not my mother tongue and the questions had to be clear for the participants.

11.1.2 Participants

The game I developed for this master's thesis targets young students, specifically for Norwegian students undertaking their fourth year of primary school education. The research performed in this game had thus the aim of testing a population that fell in this category. The first task was to get in contact with a school in the Trondheim area and ask for their

cooperation; however, only negative or null answers were received. Nevertheless, another school was contacted and they were positive about testing the game with a sixth year class and afterwards with some kids who are part of the after school activities in the SFO program.



Figure 11.1: The place where the game test took place.

Hence, the population included a total of 57 students who are undertaking different levels of primary school education going from first grade up to sixth grade. The students tested the game in at least one of its different modes, however they were able to see other modes been played by being in the room and waiting for their turn or by watching from a window.

11.1.3 Game Evaluation Place

The game was tested in a school which is located outside Trondheim, yet still inside the area known as Stor-Trondheim. The school has been remodeled recently and offers an educational environment in which the students have a big amount of freedom. The game was tested inside the premises of this school in a multimedia room which is situated beside the sixth grade classroom. The room was spacious enough to place the Kinect device and have up to two students at the same time playing. Moreover, there was space

for four more students that could be standing and watch the others play. There was also a bench and a table where the students that were done playing could sit down to answer the questionnaires and being interviewed if applicable. The room was also equipped with a projector that was used for providing a bigger screen for the visualization of the game. As the room was connected directly to the classroom, other students were able to see different play sessions while they were taking place through a window and glass door between the classroom and the multimedia room. The place has one entrance which was used for students for entering the room when new participants were required and when others were done with the game session and the questionnaires.

11.1.4 Test Interaction

It was important to test the game with only willing participants, hence all of them were asked if they wanted to play and their preferences were respected.

The students came into the room in small groups in order to have enough space for playing while other could watch or take the questionnaires or interviews. The participants were asked to play at least in one of the game modes. However, if there was time, which means they had no tasks to perform in their classes, and if they were willing they could participate again by playing in another mode.

A detailed explanation was given to the first group because they would not have the opportunity of watching other players before. Once the first group obtained a clear explanation a rotation of students took place, the newcomers were able to see other participants playing so no more detailed explanations were needed. To some of the participants it was asked if we were allowed to take pictures while they were playing.

After each student or group of them was done playing, they participated answering a questionnaire and taking part in an interview if they were asked to. After they were finished they were thanked for their participation and chocolate, as an appreciation token, was given to them. They were also asked to tell the rest of the classroom that there was place for more participants for testing the game.

11.2 Questionnaires Results

A total of 57 questionnaires were applied during the game test, hence it included all the kids that played the game. The questionnaire was designed to serve as a tool to answer the RQs and to get important information for the game as a product that could be useful for further development. A complete description of the questionnaires can be seen in Section 3.5. The present section shows a summary of the questionnaires applied to the kids. A complete version of the questionnaires and the answers of the students can be seen in Appendix A.

11.2.1 Players' Information

This section of the questionnaire is composed by five questions that get important information regarding the demographics of the participants.

Q1. Gender

The gender of the participants was important because there are some differences between male and females when it comes to gaming. From the 57 participants 29 were boys representing the 51% of the total population, 49% was composed by 28 girls.

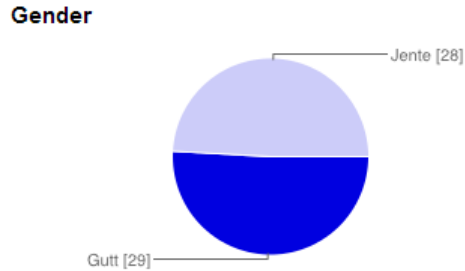


Figure 11.2: Gender distribution among the participants.

Q2. Age

Since the population was quite similar in age, it was better to separate them according to the school grade. The population was composed in its majority by sixth graders, representing up to 67% of the total participants, the rest was composed by a combination of kids going through the third, second and first year of primary education. This can be seen in better detail in Figure 11.3.

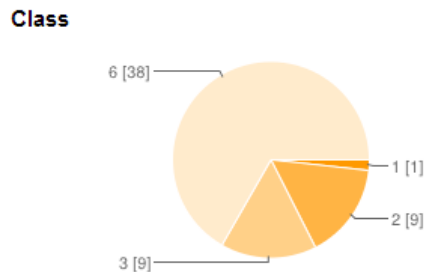


Figure 11.3: Distribution of the participants according to their school class.

Q3. Game Exposure

This question aimed to measure the amount of time the kids spent playing video games. It is useful to know how familiarized they are with the use of this media. Moreover, it could be a factor that affects their performance. The question was designed as a 5 levels scale in which the participants could choose from 1, that meant that they never play video games,

up to 5 which means they always play video games. The results obtained show that the average playing time among the participants was 3.087, which means that the population plays “sometimes”. The distribution of the results can be seen in Figure 11.4.

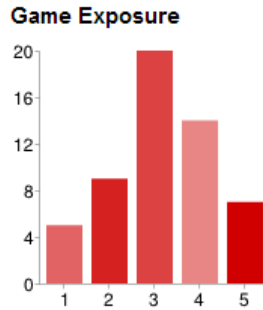


Figure 11.4: Answer of the participants regarding how often they play video games.

Q4. Educational Games Exposure

The vast majority of the participants had some kind of experience with educational games that they had used in school or at home. The survey detected that 50 of the participants played a game with a learning purpose, only 7 of them had no previous experience.

Q5. Motion Capture Experience

Since the game uses motion capture as the main interaction mechanism, it was important to know the previous experience of the players with motion capture, because it could have some influence on the performance of the players in the game. Luckily, up to 95% of the players had had some kind of experience with games that use motion capture as its main input device. A decomposition of these numbers can be seen in Figure 11.5 which also show which system they were more used to play with. It is important to note that some of the participants had experience in more than one system.

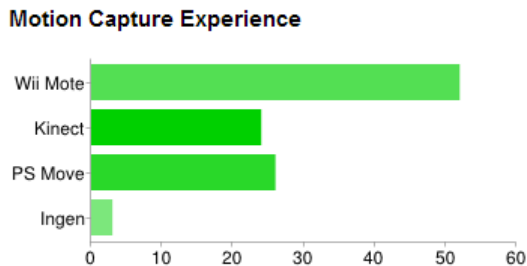


Figure 11.5: Experience of the participants with motion capture technology.

11.2.2 Learning

This section in the questionnaire aimed to measure the usefulness of the game as a learning tool. This usefulness was measured according to the opinions of the participants about how much they learned and how likely it was for them to use what they had learned.

Question	Str. Disagree	Disagree	Neutral	Agree	Str. Agree
Q6	0 kids ~ 0%	4 kids ~ 7%	4 kids ~ 7%	6 kids ~ 11%	43 kids ~ 75%
Q7	2 kids ~ 3.5%	2 kids ~ 3.5%	6 kids ~ 11%	12 kids ~ 21%	34 kids ~ 61%
Q9	4 kids ~ 7%	3 kids ~ 5%	13 kids ~ 23%	10 kids ~ 18%	27 kids ~ 47%

Table 11.1: Perceptions of the participants regarding learning in the game.

Q6. Learning in the game

The participants indicated how much they learned about recycling, more concretely about waste separation. On a scale from 1 to 5, where one indicates that they learned almost nothing and 5 indicating that it was clear to them how to perform recycling, the participants in average answered that the game helped to learn about recycling on a level of 4.54 with a standard deviation of only 0.9. A clearer distribution can be seen in Figure 11.6 and Table 11.1.

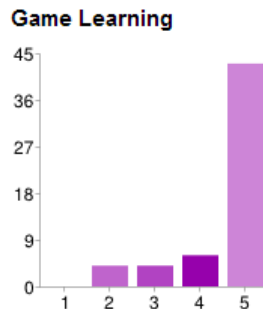


Figure 11.6: Distribution of the responses of the participants to Q6.

Q7. Game Usefulness

This question was designed to capture the opinion of the participants regarding the usefulness of the game, in other words how much they considered that the skills obtained by playing the game would help them to recycle in real life. The results obtained through the responses of the participants can be seen in Table 11.1.

Q8. Learning Preference

It was interesting to know the learning preferences of the students after playing the game. This was done by asking if they would prefer to learn more about recycling in a class or with a game. According to the responses of the students, up to 82% would prefer learning in a game like the one developed in this master's thesis, while only 18% prefers to do it in a class in the regular teacher-student interaction.

Q9. Game Usefulness Outside

It is important that the skills acquired by playing the game can be translated into everyday skills. This question addresses this topic by asking the participants how likely they were to use what they learned in the game for recycling at home. 47% answered that they were very likely to use the skills at home, followed 18% saying that they would use these skills. 23% were undecided so remained neutral, while 5% said that they do not agree that they will use these skills at home and 7% strongly disagreed in the matter, this can be viewed in Table 11.1.

11.2.3 Fun Concepts

This section in the questionnaire was composed of only one question used to capture the opinion of the participants regarding the game as an educational and fun media.

Q10. Game Motivation

It is important that an educational game is fun and motivates the players to learn. Regarding this issue, 72% of the participants strongly agreed that a fun game motivates them to learn, this number was followed by 18% of the students agreeing on the same. 7% remained neutral and only 2 students thought that a fun game does not motivate them to learn.

Figure 11.7 shows a graphical representation of these results.

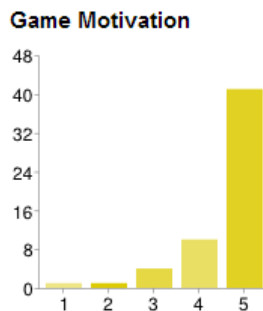


Figure 11.7: Motivation levels of the participants when learning in games.

11.2.4 Motion Capture

This section in the questionnaire contains questions regarding the opinions of the participants about the use of Kinect as the motion capture device used for the interaction in the game.

Q11. Motion Capture Interest

This question reflected the preferences of the students regarding the use of motion capture in comparison of other devices such as keyboard and mouse. The results point out that the use of Kinect was more interesting for the participants than other conventional interaction mechanisms such as keyboard or controller. A detailed description of the answers got in this question can be seen in Table 11.2.

Q12. Motion Capture Motivation

Another important aspect to look into was how motivated the students felt about playing by seeing that Kinect would be the device to be used to control the game. The results indicate that the participants felt motivated towards trying out the game because it was using motion capture, Kinect in this case. The results can be seen in detail in Table 11.2.

Question	Str. Disagree	Disagree	Neutral	Agree	Str. Agree
Q11	3 kids ~ 5%	1 kid ~ 2%	7 kids ~ 12%	1 kid ~ 2%	45 kids ~ 79%
Q12	3 kids ~ 5%	1 kid ~ 2%	5 kids ~ 9%	9 kids ~ 16%	39 kids ~ 68%

Table 11.2: Perceptions of the participants regarding the use motion capture in the game.

11.2.5 Social Aspect

An important area of research was studying the social preference in players when using a motion based educational game. This section was composed by three questions that inquire on how the students play usually, in a social sense, and their preferences of social gaming in the game developed in this master's thesis. Since the distribution of answers was more balanced in this section, I decided to show results according to the gender of the participants.

Q13. Social Preference

This question aimed to get information regarding how the participants usually play. It was found that even though the majority of the students played in single player modes, represented by 52% of the population, it was quite similar to the percentage of the participants who played in multiplayer mode, 48%. A detailed description separating the social gaming preferences by gender can be seen in Table 11.3.

Gender	Single Player	Multiplayer
Female	13 kids ~ 46%	15 kids ~ 54%
Male	17 kids ~ 59%	12 kids ~ 41%

Table 11.3: Social gaming preferences of the participants by gender.

Q14. Exposure in the Game

It was important to ask the players which game mode they played. Some of the players experienced more than one game mode and hence the total number of players in this question is bigger than the actual population. In total, 12 players -18%- played the game in single mode, 35 -52%- played in cooperation mode and 20 -30%- made use of the versus mode in the game.

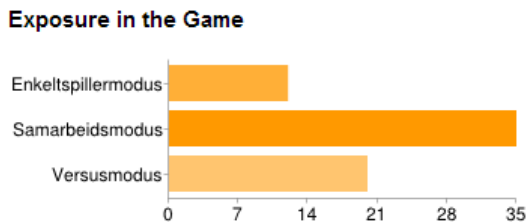


Figure 11.8: Game modes played by the participants.

Q15. Game Mode Preference

The players also indicated which mode in the game was their favorite. Some of the players, however, did not have the chance to visualize all the game modes and hence their game mode preference was not captured. In total, the majority of the participants indicated that they prefer one of the multiplayer modes with 94% -49% cooperation mode and 45% versus mode-. Gender specific results can be seen in Table 11.4.

Gender	Single Player	Cooperation	Versus	No Answer
Female	0 kids ~ 0%	16 kids ~ 57%	8 kids ~ 29%	4 kids ~ 14%
Male	3 kids ~ 10%	9 kids ~ 31%	15 kids ~ 52%	2 kids ~ 7%

Table 11.4: Game mode preferences of the participants by gender.

11.2.6 General Information

This section in the questionnaires does not address any of the research questions studied in this master's thesis, but they obtain useful information for the game as a product and could help to improve the game in the future and work as future reference for other games. The summarized results can be seen in Tables 11.511.611.7.

Q16. Game Goal Easiness

This question captures the opinion of the players regarding how easy it was for them to understand the purpose and the rules in the game. The results can be considered as positive since 84% of the participants understood the game goal to some degree. There were some isolated cases where the goal was difficult for the players to perceive.

Q17. Menu Controls Usability

The results regarding the usability of using the menus with the motion capture device were inconclusive. Just little over 50% of the population thought that they were easy up to some degree. But at the same time almost 25% expressed that they had some kind of difficulties with them. These whole result can be seen in Table 11.5.

Q18. Game Interaction

The majority of the students indicated that the interaction with the game was good, 33% indicated it was very good, 32% said it was good. However, even though a small part of the population thought it was bad, more than a quarter of it expressed their neutrality towards it.

Q19. Gestures Usability

This question captured the opinions of the participants regarding how well designed the use of the movements in gameplay were. The results are quite positive indicated by up to 84% of the participants saying that the gestures were suitable and well designed. A more detailed distribution can also be seen in Table 11.5.

Question	Str. Disagree	Disagree	Neutral	Agree	Str. Agree
Q16	0 kids ~ 0%	1 kid ~ 2%	8 kids ~ 14%	13 kids ~ 23%	35 kids ~ 61%
Q17	3 kids ~ 5%	11 kids ~ 19%	11 kids ~ 19%	13 kids ~ 23%	19 kids ~ 33%
Q18	3 kids ~ 5%	1 kid ~ 2%	16 kids ~ 28%	18 kids ~ 32%	19 kids ~ 33%
Q19	1 kid ~ 2%	2 kids ~ 4%	6 kids ~ 11%	11 kids ~ 19%	37 kids ~ 65%

Table 11.5: Perceptions of the participants regarding learning in the game.

Q20. Initial Difficulty

Ideally the initial difficulty should have been perceived as neither too easy nor too difficult. The majority of the population perceived it as so with up to 44% . However, there still a big number of participants that indicated that the difficulty was too easy.

Question	Too Easy	Easy	Neutral	Difficult	Too Difficult
Q20	18 kids ~ 32%	4 kids ~ 7%	25 kids ~ 44%	8 kids ~ 14%	2 kids ~ 4%
Q21	5 kids ~ 9%	8 kids ~ 14%	32 kids ~ 56%	7 kids ~ 12%	5 kids ~ 9%
Q23	17 kids ~ 30%	4 kids ~ 7%	14 kids ~ 25%	12 kids ~ 21%	10 kids ~ 18%

Table 11.6: Perceptions of the participants regarding the difficulty in the game.

Q21. Difficulty Increase

The speed at which the difficulty increased in the game was rather good according to the perception of the players. The difficulty increase results are positive indicated by most of the participants thinking that it was neither too slow nor too fast. Some of the participants indicated that the difficulty increase was fast or slow but not too extreme, which I consider acceptable due to the different game related skill level of the participants.

Q22. Game Graphics

It was important to also get the opinions of the players regarding how good the textures used in the game were. Even though it is common nowadays to have very complex 3D graphics in games, 77% of the players thought that the graphics used were very good and 16% said they were just good. A very small part of the population actually thought they were bad. The distribution can be seen in Table 11.7.

Q23. Game Elements Identification

This questions aims to capture the perceptions of the players regarding the easiness to separate and identify the different elements of the game, especially during gameplay. The results of this question are inconclusive due to a very even distribution of the perceptions of the players. This case can be better described in Table 11.6. It is important to note that the game suffered from image degradation while being played with the aid of a projector.

Q24. Game Sounds

The last questions of the questionnaires looked into the quality of the sounds used in the game. The sounds, similarly as the game graphics, were well received with up to 82% of the participants indicating that the sounds used in the game were of high quality.

Question	Very Bad	Bad	Neutral	Good	Very Good
Q22	1 kid ~ 2%	1 kid ~ 2%	2 kids ~ 4%	9 kids ~ 16%	44 kids ~ 77%
Q24	1 kid ~ 2%	2 kids ~ 4%	7 kids ~ 12%	7 kids ~ 12%	40 kids ~ 70%

Table 11.7: Perceptions of the participants regarding the quality of the game assets.

11.3 Interview Results

This section describes the most important data obtained during the interviews applied to some of the participants. The information presented in this section is important because it helps answering the RQs which this master's thesis aims to study. In total, eight participants were interviewed, and this was performed as a couple-interview because it felt easier to perform and the kids did not feel intimidated by being alone. It is important to note that this section only includes the answers given by the participants in a summarized manner, however, it is possible to see the whole interviews' transcripts in Appendix B.

11.3.1 Learning Preference

A specific question in the interview inquiries the participants about what they think was good about learning through the use of a video game. The answers of the students were similar because all of them thought that one of best benefits someone gets by learning while playing a game is that they have the opportunity to learn at the same time that they actually get to practice and perform activities while learning. This as well seems to be preferred by them because it results in an activity which is not boring for them and easier to remember. For instance a couple of students said the following during the interviews:

“Interviewee 7: Ehmm...If it is like this learning video game, then I think it is really fun to play and learn something new. So, one does not only listen to what some person says about it.

Interviewee 8: I actually agree with that. It is the easiest to learn something by doing it, like for example in the game, than being sitting with a book and writing.”

11.3.2 Fun Concepts

One common topic regarding the concepts that made the game fun for the participants was the use of Microsoft's Kinect. They thought it was more entertaining to control the game with their movements than just sitting down.

*“Interviewer: What do you think it was fun in the recycling game?
Interviewee 7: Ehh, that one kind of can do this with the hands instead of sitting in front of the computer.”*

Another thing that was detected as a fun factor in the game is the difficulty increase in the form of the speed at which the objects travel through the conveyor band and the need for them to look carefully and decide in which container an item belonged.

“Interviewer: Ehh what do you think were fun things in this recycling game like the one you played?”

Interviewee 3: Ehh, that it went faster.

Interviewee 4: Yes, that in the start, it was quite simple, and then it went just faster and faster and then you had to concentrate”

Other of the participants who played in the cooperation mode found that it was fun to have to coordinate among them in order to get the items recycled in the correct container and thus earn more points.

The game was not perfect according to the opinions of some of the interviewees though. The participants were asked what they would change about the game in order to make it more entertaining. Even though some of the students did not have a clear idea, others commented it would be good to make the game a little more interesting by introducing more items to recycle, the speed difficulty and as well more bonus items because, for at least one of them, it was a very fun concept especially in the versus mode. These opinions can be seen in the following responses.

“Interviewee 3: Ehh that maybe should have been ehmm...little more things that came more often.”

“Interviewee 7: Ehh maybe it had...hehe. Little more things for example watermelon, fruit, old watermelon. And like different. And little more bonus things. So it makes it more difficult for the opponent.”

Other students detected that there were problems with the visualization of the items, however, this was due to the image given by the projector, but it is still a valid point.

One of the interviewees also said that it was sometimes difficult to perform the movements and that it should be changed in order to make the game better.

“Interviewee 1: Ehh maybe had some simpler controllers because it was little like, you had to twist the hand...”

11.3.3 Game Reusability

The interviews also served as a tool to find out in which other domains the same game concept could be used. The interview inquired the participants about in which other areas they considered that the game could be used as well to learn something by still keeping the same game concepts. It was interesting to note the different ideas that the students had and which means that the game can be reused at Cyberlab's discretion in the future.

One of the kids said for example that the game could be applied to any kind of class that is taken at school such as math, geography and Norwegian. He mentioned that for instance it could be applied to help them learn arithmetic. This can be seen in his answer.

“Interviewee 1: Ehm, if for example it had been the same, but it had been in math. For example, if you had for example five times, something, and then

had a box where the answers were given and then just do exactly the same and push the equation in the trashcan.”

Another student mentioned that it could be used in more religious topics such as helping identifying different concepts in the Christian religion.

“Interviewee 7: Maybe like for example. Like what came from Egypt and...I don’t remember how the class is called, but in a class we learned about Jesus. About Christianity. You can have Jesus in one side and other things in the other side.”

11.3.4 Motion Capture

The use of motion capture was quite important in this project, so it was interesting to try to get some of the information regarding the use of this technology, in this case with Kinect. The interview asked the students their opinion about the use of Kinect in the game. All of the interviewees thought that it was a good idea that only made the game more entertaining to them and was a better approach instead of using other input mechanisms.

For instance here are the extracts of some of the interviews:

“Interviewee 1: Eh, I think it was a lot of fun when you have to move instead of being seated and pressing the keyboard or holding a controller.”

“Interviewee 5: Very cool!”

“Interviewee 7: I think it was brilliant!”

11.3.5 Social Aspect

The interview also tried to get a more deep opinion of the participants regarding the game mode they liked the best and their reasons. This is important because it helps in finding what game mode or social interaction is more appealing for the participants and hence more motivating.

In summary it can be said that all the participants in the interview indicated one of the two player modes as their favorite and none actually mentioned the single player mode. It is important as well to note that in some cases some of the players completely forgot about the single player mode and talked about the “two game modes”.

In regards to which of the two player modes they liked the best there was no conclusive answer, because both modes had a similar amount of supporters. However, similarly as with the questionnaires, it could be seen that girls were more inclined towards the cooperation mode while the boys were with the versus mode.

“Interviewee 2: No, I liked really both of them the same.”

11.3.6 General Information

This last section of the interview contained one question aimed towards the reception of the game as a product, hence even though it can be useful for detecting areas of opportunity in the game, it is not as relevant for the research undertaken in this master’s thesis.

The responses of the interviewees here were shorter than in the rest of the interview, and they could be summarized in that the students really enjoyed the game and thought it was a good way to learn new things and which could be really good to have in the classroom.

11.4 Observation Results

Even though the observation was done to every single game session, I manage the whole game evaluation as a single observation. However, I divide this section into the technical difficulties observed during the evaluation, the session held with the sixth graders, and the testing performed with the SFO students.

11.4.1 Technical Difficulties

Even though the game was tested previously for correct performance, some difficulties arose because of the installations where the game was tested. This does not mean that the installations were inadequate, but that such circumstances were not foreseen.

The most critical difficulty was the fact that the Kinect device was not working correctly. The game was not performing the movements done by the players and started to randomly move game elements. It was noticed that this situation was occurring because sometimes the players moved from the horizontal range of the camera and stopped being tracked, and then the device was able to track one of the students that were outside the room looking through the glass door. The situation was solved by placing a board that was in the room in front of the glass door, even though this could have seen mean towards the rest of the students in the other room, it was a necessary action and they were still able to observe the game sessions through two different windows that were shared between the multimedia room and the classroom. Another important difficulty that took place was related to the visualization of some of the items in the game. Some of the students expressed that they had problems detecting some of the objects in the game, as the case of the plastic cup, and they started asking others what it was supposed to be. This situation occurred because the projector in the room did not provide with a good contrasting image of the game. The settings in the projector were changed but it was still not a perfect reproduction of the image presented in the game.

Moreover, there was a continuous problem with some of the students because they kept pausing the game by joining their hands, producing then the pause gesture used for the game. Even though it was a bit intrusive, the students did not seem to mind it too much and carried on with the game.

11.4.2 Sixth Graders Observation

The sixth year students were the first ones to try the game. It seemed that they knew that they were going to try a game during the day because as soon as we arrived, they started going towards us and asking if we were the “game people”.

The kids were told that only small groups at the time would go into the room where the game was being tested. The first students went in and wondered how the game was going

to be played. As I told them that the game was using Kinect so they would actually control it with their movements, they expressed that that was “cool” and they seemed really enthusiastic about testing the game. At the same time it was easy to see the rest of the kids looking through the glass door and windows between their classroom and the multimedia room where we were testing the game.

While some of the kids seemed a little bit shy or embarrassed about performing the movements needed to play the game, there were others who were jumping and asking all the time if it was their turn already. One of them asked us if he could get the game at GameStop.

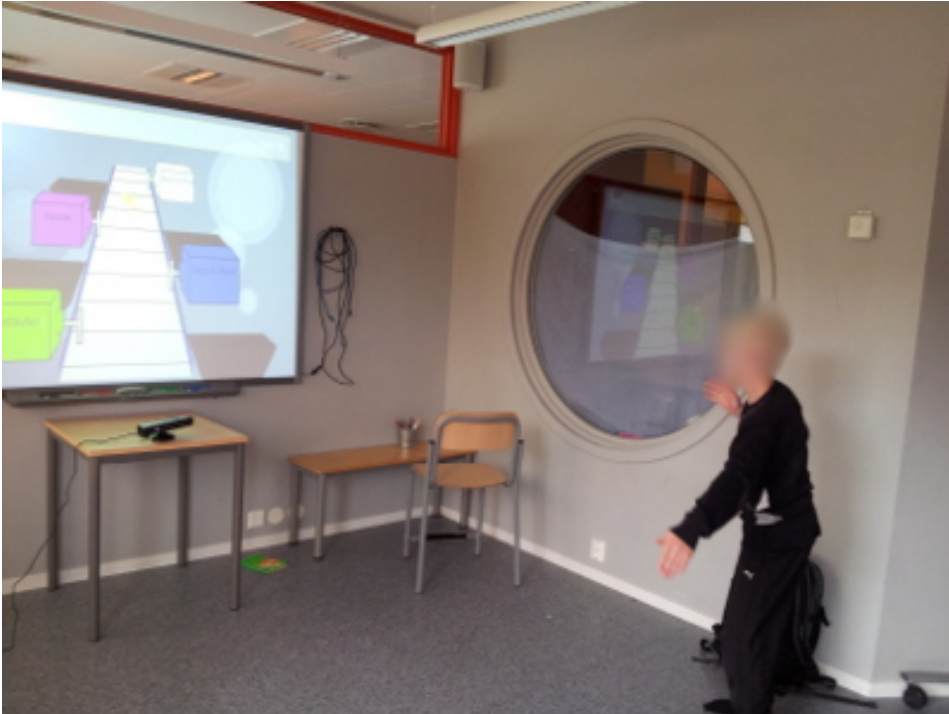


Figure 11.9: An enthusiastic kid playing the game in arcade mode.

For the first round of game sessions the kids were passing in couples and when one couple was done the next one came in. We noticed that it was quite tiresome to do a small demonstration of how the game was played, so we decided to get the kids in groups of four. Every time two players were done with the questionnaire or interview, they told the kids outside that more players were required, hence they had the chance to see the other couple playing and less explanation time was needed.

The kids seemed quite eager to answer the questionnaires when they noticed that chocolate was going to be given to them afterwards.

The students playing the one player mode seemed quite satisfied, but not all of them were excited about playing the game and seemed quite nervous about being watched while they

were playing. However, there were other kids that were really having a good time and jumping and trying their best to recycle the items in the game yelling phrases such as “Oh no!”, “Fy!” or “It’s not working!” every time they missed an item. Some of the students asked us if they could play again, to which we answered that if time allowed it would be possible.



Figure 11.10: A couple of kids playing in multiplayer.

Once we got a good number of participants in the single player mode, we started with the two player mode which could be either versus or cooperation mode. The first couple of students looked at each other and smiled, they were looking very enthusiastic about trying the game with a partner at the same time. It is important to note that at this point we started allowing some couples to test another game mode if they wanted due to we were doing fine with time and they had a little break in their school activities. Most of the girls preferred to try the cooperation mode, while the boys felt more inclined towards the versus mode. It is interesting to note here that usually players that participated in a second game session were able to do better in the game by performing the different game movements more easily and identifying the recycling objects with less effort. The kids that were playing the cooperation mode continuously reminded each other their turn and pay attention to recycle the game. The kids that were watching them playing helped them out to identify the items in the game by saying for example “That is a bag,

it's plastic, plastic!”, “Milk carton, so paper!”.

One of the kids answering the questionnaire reacted to me taking pictures of other kids while they were playing and expressed his desire of also getting himself in a picture.



Figure 11.11: Kids asking me to take a picture while they were answering the questionnaires.

The kids who were playing the versus mode seemed very engaged, paying close attention to not lose any single item. Kids seemed happy about having a competition between them and were quite happy about winning. The interview was applied to those kids who seemed more enthusiastic about the game. One of them really took his time and elaborated long answers for the questions in the interview. He also asked questions about where he could obtain the game for himself, and added “This is the best game I have ever played”. Overall, it seemed that the kids who participated in the multiplayer modes were more enthusiastic about the playing the game than those kids that played it in single player mode.

11.4.3 SFO Students Observation

The tests took a small break because the kids had to perform some school activities. Unfortunately, after their tasks in the classroom they went home so it was not possible to ask other kids that participated in only one game mode to try again.

After a small wait, the SFO students came to help us trying the game. Most of the kids

asked to play the cooperation mode, while others played with the versus mode and only a couple of them asked to play alone. The SFO kids were visibly younger and the situation was more chaotic since many of them entered the room.



Figure 11.12: A chaotic session with enthusiastic SFO students.

The kids were really enjoying the game yelling at each other which type of item appeared in the game and in which container it should be deposited. However, a couple of girls seemed to be shy and did not want to participate at all even though some of their friends wanted them to play with them. Even though all of them seemed quite engaged, which was positive for the game, the situation suddenly turned out to be chaotic because all of them wanted to play at the same time and went into the play area and started to perform the movements needed in the game, which provoked some problems. The original players were not able to play correctly anymore because the Kinect device was having difficulties detecting all the different kids.

While the last kids were answering the questionnaires, the testing was declared over and I started turning off the system, suddenly two girls arrived because they had not played the game. The game was turned but at the end they decided that they rather not play after all.

Chapter 12

Discussion

The research goals established at the beginning of this master's thesis can be categorized in three different areas, the effects of motion capture in educational games, the effects of multiplayer capabilities in motion based educational games and reusability of game concepts. I start by describing the findings related to the use of motion capture in educational games and afterwards I will describe the effects of multiplayer and reusability of game concepts that in this case are closely related to the use of motion capture.

Each of the major areas is addressed by forming an answer for the research questions that compose each of the research goals in this project. This is performed by analyzing the data obtained during the literature study, in addition to the interviews, questionnaires and observation that took place during the game testing with real users.

12.1 Effects of Motion Capture in Educational Games

The use of motion capture in educational games has not been sufficiently addressed because it is a relatively new technology in the area of player-game interaction. Since one of the perceived benefits of playing games that have an educational purpose is creating a motivating environment for the players [27], it is interesting to know how the use of this new way of interacting with a game could affect the motivation, engagement and learning of educational games' players. The research questions that are relevant for this area are the following.

RQ1.1 What are the benefits of using a motion capture system in an educational game?

RQ1.2 What are the effects in the motivation, engagement and learning of players who are exposed to a motion based educational game which is used as a teaching tool?

RQ1.3 What are the advantages of learning through a motion based educational game in comparison with the traditional teacher-student interaction that takes place in a classroom?

12.1.1 Benefits of Motion Capture

According to what it was studied in the literature review, it is possible to extrapolate the benefits already found in serious games. According to Aguilera [14], games can improve the spatial, visual and psycho-motor skills of the players. While this applies as well to the game developed in this project, it is important to take into consideration the role of motion capture, which by providing a more natural interface [6] further improves the skills previously mentioned. This can be further confirmed with what was observed during the game test with real users, at the beginning the players had some problems performing the necessary movements for the game but they got quickly used to them and in the case of the participants who played twice, this becomes truer.

As it is mentioned by Griffiths [24], games are useful for learning because of the interactivity they provide. In the test of the game I developed, I could see that the interactivity was increased because the players needed to actually control the game parts with the movements of their bodies. This is further confirmed with the interviews held with the participants, where they mentioned that using Kinect was more entertaining than sitting in front of a screen pressing a keyboard or holding a controller. Moreover, according to the participants, they were able to learn about recycling through the use of motion based educational game, for instance up to 86% of the participants agreed on learning about waste separation and 82% said that this activity became easier for them. However, the data obtained in the questionnaires only capture the immediate opinions of the players after making use of the game. It would be interesting to see how regular use of the game affects the perceptions of the players in a long term basis.

Moreover, even though the players reacted positively towards using the skills learned in the game outside, for example separating wastes and recycling them at home, the results were somehow divided with over a quarter part of the participants -35%- indicating that they did not think that the skills and knowledge obtained in the game would promote recycling among them outside the classroom or the game itself, however it would be interesting to see if the game would still be able to affect them in a subliminal level.

As a whole, the motion based educational game seemed to enhance many of the benefits detected already in serious games. Even though there is no strong indication that the skills learned in the game can be used outside of the learning environment, there are strong hints that the message and domain concepts which the game aims to communicate and teach to the players is being successful according to the perceptions of the players. With the current data obtained from the participants, it seems that motion based educational games could become a valuable tool for the education of young students.

12.1.2 Motivation, Engagement and Learning

Since the use of motion capture provides a new way to interact with the games, it is interesting to look at what this new manner of controlling the game affects the motivation, engagement and learning among the players.

During the evaluation of the game I was able to find that the participants were excited about learning in a game, this could be seen in the observation performed where it is noted that the kids were excited about trying out the game, moreover, this is further supported by the 90% of the participants that agreed at different levels that they feel motivated when

they get chance to learn with the use of a game.

Regarding the use of motion capture in the game it was clear that the participants were more motivated towards playing a game that used Kinect. Up to 81% of the participants expressed that they think that playing a game using Kinect is more entertaining than using other conventional mechanisms such as controllers or keyboards. Moreover, 84% of the players wanted to play the game I developed because it made use of motion capture.

While these numbers seem promising, it is important to take into consideration that the use of motion capture devices in games, in which possibly the users are exposed to others while playing, could create an uncomfortable environment for more introverted persons. This situation was clear with the two girls that seemed to be shy and did not want to play the game. Even though this seems to be as an isolated case, it could become important while studying even larger populations.

The game was also successful in engaging the players. I was able to observe that the players were paying close attention to the game because they wanted to get a higher score than their opponents or because they did not want to let down their teammates. A player also mentioned in one of the interviews that he had to concentrate in order to coordinate his movements and react accordingly to the item that was presented in the game. Moreover, the engagement was not only exclusive to the participants making use of the game. It was also clear that the spectators of the game became engaged into the gameplay because they were participating, trying to help the current players by telling them which kind of item was next in the game and how they should perform the movements to recycle said items.

The increased levels of motivation and engagement provided can be related to the learning benefits described previously in the benefits of motion based educational games. The interactivity provided by the Kinect device was also helpful because as Malone [32] argues, by arousing the sensory system of the players it is possible to provoke curiosity among the players which creates a fun environment ideal for learning.

However, through the use of the interviews I also detected that the game could become more motivating and engaging if some technical issues are solved. For example, if the game is planned to be used with a projector it is important to provide clear images which are not difficult to spot and easy for the users to identify. Moreover, the game could make use of better gesture mechanics in order to be more responsive towards the users' actions and avoid presenting an extra challenge to the players that they were not expecting.

The use of motion capture in educational games, however, seems to be promising in regards to motivation and engagement among the players and hence increasing the effectiveness of the game as an educational tool. Nevertheless, it is important to design a good interaction with the motion capture device in order to not frustrate the players with unresponsiveness from the system which could affect the experience of the player and decrease the success rate of the game.

12.1.3 Advantages of Learning with a Motion Based Educational Game

The advantages of learning in a motion based educational game in comparison with learning in a classroom with the traditional teacher-student interaction are closely related to the preferences of the students and the learning benefits that can be obtained through the use of games and motion capture.

For instance, I asked the participants in the questionnaire if they would prefer to learn

about recycling in the game like they just played or in the classroom. It can be detected that most of the players would prefer to learn in a game -82%-, nevertheless there is still an important fraction of participants that would rather keep learning in a classroom through the information given to them by the teacher. I think these numbers indicate that even though motion based educational games can be good tools for learning, they still need to be combined with more traditional approaches in order to address the whole student population and as well address other issues that cannot be monitored through the use of a game. According to what the participants replied in the interview regarding the advantages of learning in a motion based educational game, some of the advantages are directly related to the motivation levels a game can arouse within the players. One common answer among players regarding this issue was that the games made the learning process fun for them, in other words they did not feel that learning about recycling would require them to do amounts of tedious work as they would by doing other activities such as homework. Moreover, besides making learning fun for the students, games can provide a learner-centered environment in which according to Stapleton [54] the users can form their own concepts instead of just trying to memorize what the teacher says as it happens in the traditional teacher-student interaction. This learner-centered environment could be seen during the evaluation of the game among children, where the kids instead of waiting for someone to tell them in which container each item should go, they started to form their own knowledge by classification the item and depositing it in the right place.

It can be concluded then, that motion based educational games present the same advantages over the traditional teacher-student interaction as other educational games do. Nevertheless, these findings are still important because it proves that by introducing motion capture into educational games, the perceived benefits of using the game as an educational tool are still preserved and hence useful, and by adding the different benefits encountered in RQ1.1 and RQ1.2 they become a potentially very useful asset for the education of young learners.

12.2 Multiplayer Features in Motion Based Educational Games

The game experience while playing in a multiplayer environment is different in comparison to playing in single player mode. In this project the study of multiplayer capabilities in the motion based educational game is studied in order to see how they affect different characteristics related to the effects of the game among the players.

In this game I created a single player mode and two multiplayer modes, cooperation and versus, which fall under the categorization of multiplayer described by Smith [50], more concretely as cooperative and competitive multiplayer games.

This area in the research undertaken in this project is approached through the use of the following research questions.

RQ2.1 What are the players' social preferences in a motion based educational game?

RQ2.2 How are the effects in the motivation, engagement and learning of players in a game with a social component compared to a single player game?

12.2.1 Social Gaming Preference

In order to analyze the social gaming preference of the participants in the motion based educational game I developed for this master's thesis, it is important to know the preference of the participants before they tried the game. As I expected, there is a big percentage of students that usually play single player games. However, the number of participants that indicated that they often play multiplayer games is quite similar so there is no concrete evidence to affirm that they prefer one more over the other. Nevertheless, it is interesting to notice that even though the numbers are very similar, boys tend to prefer single player games and girls present a bigger amount of players in multiplayer.

In order to see the preferences of the participants regarding which mode they preferred in the game developed in this project, they participated in different game sessions. Only some of the players had the opportunity to try two of the game modes but at least they all had the possibility to observe other game modes while other students were playing. The results show that the cooperation mode was the most played followed by the versus mode and at the end the single player mode followed. It is important to mention that the players who had the opportunity to try the game a second time usually did it so on cooperation mode.

The results show that up to 94% of the participants indicated that they preferred one of the multiplayer modes. Here it is interesting to note that girls' preference was inclined more towards cooperation mode while the boys preferred a more competitive environment. Nevertheless, the overall preference between a cooperative and a competitive game mode are quite similar, so it is important to consider this situation when designing a multiplayer motion based educational game. This was as well detected during the interviews where players expressed that they liked the versus mode because they had the chance to compete against someone else and had the opportunity to become the winner. On other hand, the players that preferred the cooperation mode did so because they felt it was fun to cooperate with a teammate and not have all the responsibility on only one person; players that did not feel confident on their skills or who simply do not like to lose also chose the cooperation mode, which is similar to what Vorderer et al. [61] argues in respect that players that prefer a competitive environment are those who feel confident in their skills.

The low rate preference for the single player mode could be due to two different factors. Firstly, it is possible that being exposed to others while playing alone and performing the gestures in front of a camera creates an uncomfortable situation that could make the player feel embarrassed. This was detected during the observation when in two different instances the players who seem shy decided not to participate into the game and in another incident, a participant only decided to play after a partner told her that they would play together. The second factor is related to the nature of the environment where the game evaluation took place; by being in a room surrounded by peers, playing in a multiplayer mode could result in a more entertaining experience for the users.

It can be argued then, that the game mode preferences of a motion based educational game can be decided by a combination of the players' confidence, the environment in which the game is being played and the gender of the players. However, I consider it is important to provide alternatives in order to cater as many players as possible.

12.2.2 Effects of Multiplayer Capabilities

It is expected that multiplayer capabilities in a motion based educational game has effects on the motivation, engagement, and hence the learning process of the players.

According to the results obtained in the questionnaires, a big percentage of the participants actually felt motivated towards playing the game because it made use of motion capture. This could be caused by the novelty of controlling a game through the use of movements. It is important to have in mind that the use of motion capture in games as an interaction mechanism is relatively new, moreover, due to the more natural interface they provide [6], it is possible to augment the interactivity between the players and the game because they get to use their whole body instead of only their hands as it would be in the case of more conventional mechanisms such as keyboards and control pads. And it is this interactivity that makes the engagement of the players in the game more intense which at the same time promotes learning among the players, coinciding in this way with Griffiths [24] argument regarding the benefits of games in education. However, there is strong indications that adding multiplayer capabilities in the game can create a more motivating and engaging environment for the players. This can be seen by the number of players that mentioned that the game mode they liked the best fell under the category of multiplayer.

The effects on the engagement of the players could also been seen during the game sessions. The students were paying close attention when cooperating or competing against another person in order to perform well in the game and win. Moreover, the audience watching others play became engaged as well trying to support them by identifying actions that were needed in the game, which means that they were learning even if they were not taking part of the game session.

Playing multiplayer games can create a sense of satisfaction among the players. For instance, as Vorderer et al. [61], players in cooperation mode get a sense of satisfaction by creating a win-win situation with their partner. This can also be extrapolated and held true in motion based educational games, for example during cooperation mode sessions in the game evaluation, I was able to observe that the players were helping each other and cheering up each other's accomplishments in the game.

In the versus mode, on the other hand, satisfaction of the players was obtained through besting the other player. As the game in this mode presented an extra challenge in the form of a human opponent, it was able to kept players who like competitive games motivated for a longer time. Moreover, as it is argued by Malone [32], challenge can contribute to make a concept fun to learn, hence the game becomes a successful tool for learning. With competitive players this game mode is perhaps better suited for providing increased levels of motivation and learning, because at some point the players are 'forced' to learn in order to beat their opponents which is what they are looking for as it was capture in the expressions of some of the players that mentioned that they preferred the versus mode of the game during the interviews.

The success of the multiplayer modes in regards to the motivation, engagement and learning can also be stated by the amount of players that preferred one of these modes over the single player mode. Moreover, as mentioned before the audience seemed as well more interested in what was happening in the game during the multiplayer sessions than during the single player sessions. In this game the multiplayer modes showed to be more effective in arousing the motivation and engagement levels among the players.

12.3 Reusable Game Concepts

Another focus point of the research undertaken in this master's thesis is the reusability of game concepts in order to not limit the scope of the game to recycling but to expand it to other learning domains. The idea is that the game remains as similar as possible to the prototype being developed here and with only adjusting some variables they can be used to help in the learning process of another subject.

The motion based educational game has many concepts that could be reused in order to streamline the development efforts and reduce its cost. It is then interesting identifying the concepts that are worth reusing and how they can be reused.

The research area covered in this project addresses the reusability of game concepts of a motion based educational game by answering the following research questions.

RQ3.1 What game concepts are fundamental for a motion based educational game to be considered fun?

RQ3.2 How can these concepts be reused for learning purposes in a different domain?

12.3.1 Reusable Game Concepts

The game I developed during this master's thesis consists of many parts that could become potentially reusable. However, the most interesting assets that could be reused are those related to the game concept because, differently from other software components, game concept reusability require more than only a modular structure, for example.

Identifying those concepts that were fun in the game according to the participants is a good starting point to decide the game concepts that could and should be reused. For instance, the participants expressed during the interviews that one of the things that made the game fun to play was the use of motion capture. So, it can be argued that the gestures used in this game could be reused in future implementations. However, as other participants identified and I observed during the game sessions, the gestures' design should be more robust in order to not frustrate the players with an unresponsive game or a game which responds to actions that the player was not planning to perform.

Moreover, the increment of difficulty by accumulating points in the game was a concept that the players also were fond of. The participants thought it was interesting to play the game because even though at the beginning it was slow and the difficulty was quite easy, this suddenly started to change due to an increment of the game difficulty that reacted to the players' actions. This situation demanded a more focused and concentrated players who otherwise would have not stand the challenge presented by the game. This incrementing difficulty is related to what Malone [32] recommends to include in a game as it constitutes the challenge that keeps the players motivated and makes the pedagogical concepts in the game fun to learn. The combination of the gestures used and the manner in which the difficulty increased in the game are tightly related with the idea of having a conveyor band carrying items needed for the interaction of the players with the game; hence it could be a game concept that could be reused.

In addition, Malone [32] also argues that it is recommended to add a feeling of uncertainty that will arouse the players' curiosity which at the same time keeps them motivated and engaged in the gameplay. This curiosity is provoked in the game with the help of the bonus

items which add randomness into the gameplay flow. Moreover, the bonus items were also noted to be interesting for the players whom also said they would like to see more in order to make game more entertaining.

In addition, by analyzing the results it is also important to keep in mind that the multiplayer game modes were voted as the favorites of the players. It can then be argued that offering multiplayer capabilities to a motion based educational game increases its chances of becoming fun among the players. Nevertheless, I consider it necessary having a single player mode as well since it provides the basis for the multiplayer modes and could be the only way to experience the game when no more than one player is present.

Even though there could be more game elements and concepts that could be reused, the evaluation of the game I developed in this master's thesis shows that the mentioned features were the ones preferred by the participants. Moreover, these concepts seem to have a solid theory foundation regarding their nature and their role in making elements of a serious domain fun to learn.

12.3.2 Reusing the Game Concepts

The game concepts identified previously can then be reused in another game. The basic premise here is not to change too much about the game developed but adjusting it to a different learning domain.

I detected that it was possible to have the same concept in different domains as long as the pedagogical concepts could be used in a classification scheme as it happens in "The Recycle Game" where the players have to categorize the incoming items and deposit them in the right container. This case is similar to what happens in most of the games that fall under the "quiz" genre. For instance, "Lecture Quiz" developed by Wang [62] was tested in a Software Architecture class, but by modifying the underlying pedagogical concepts, it is possible to adapt to different domains. The same principle could be applied to the motion based educational game I have developed for this master's thesis, by changing some of the game assets such as the items and pistons in an XML configuration interface I was able to adapt the game to a math domain in which the goals is the correct classification of numbers. The reusability of the game concepts in another domain was also captured in the interviews held with the participant. According to the results, the players thought that the game could be reused in almost any of the courses they take in school such as math, language and geography. Nevertheless, the description they gave about such possible games still fell under the classification genre.

It can be argued, however, that the different game concepts can be reused in other kind of games that do not hold an underlying educational purpose. For instance, the bonus items can be reused as element of randomness in many games that uses items as the objects the player needs to collect in order to accomplish the goals. Moreover, the movements used in the game could be interesting for exergames that seek to rehabilitate patients with motion difficulties; however the movements used in the game I developed have not physician or expert basis so they must be redesigned.

As it can be seen, the reusability of the game concepts of "The Recycle Game" is very limited when the target is an educational game. However, the same situation can be described when talking about other game concepts that try to embrace as many domains as possible. It is very difficult to design a game that could be reused in different domains

and at the same time have reusable game concepts that could be used in games completely different from the one they inherit. Nevertheless, the game concepts that were detected as important to be reused in motion based educational games can be adapted to different learning domains and in this manner effectively exploiting them.

12.4 Used Technology

The technology used in the development of the game prototype is not related to the research undertaken in this master's thesis. However, it is an important part of the project and hence its evaluation is interesting.

In this project I used technology tightly related to Microsoft, namely XNA and Kinect. It is important to note that even though the use of these technologies was successful for developing the game prototype, it forces the game to be played in platforms that are supported by Microsoft, such as Windows and Xbox.

Firstly, Kinect is an affordable motion capture device that is being supported increasingly by Microsoft. The libraries provided and the big amount of example projects makes it easy to take in the technology and start developing.

In regards to the performance, the device responded accurately to the gestures made by the players during the game evaluation even though they could have been more robust. However, there are some issues regarding players tracking because the device can make mistakes when there are loud noise sources or when the players go out from the tracking range.

Nevertheless, during the game evaluation, the children seemed to enjoy using the device to control the game, but there is still little evidence to support that Kinect is the most ideal or preferred motion capture device to them.

In regards to the framework used for game development, XNA provides the developer with libraries and abstractions levels that eases the programming efforts in a great degree. Much of the tedious work like the access and use of low level libraries such as input, sound and graphics is already done by the framework alongside the game loop. Moreover, there are many useful third party libraries and examples that further eases the development efforts. Due to these benefits, I only needed to focus on designing the gameplay and game assets.

In addition, even though it was not needed in this project, there are possibilities of porting the game to different platforms. However, they must be Microsoft supported platforms such as Windows, Xbox 360 and Windows Phone.

Overall, it seems that XNA can be a good platform for developing motion based educational games. Nevertheless, the developer must be conscious that the game will be dependant on Microsoft products. Recently, it has been announced by Microsoft that they will stop giving support to the framework, it will not receive more updates and it will be completely retired by April 2014 [12]. Hence it might be not a relevant tool in the future since it is not supported in Windows 8 and it will not be used for developing games for the Microsoft's new console Xbox One.

Part IV

Conclusion

Chapter 13

Summary

During this master's thesis, I designed, implemented and evaluated a motion based educational game. The project addressed a set of research goals that were established at the beginning of the project which are related to game technology.

In order to undertake the research I performed a literature review that gave me an important insight about the underlying research issues. Moreover, the literature study was as well relevant for the implementation of the motion based educational game prototype by describing the different design issues that should be addressed and the technology that could be used.

The field study was performed in a case study manner where the main data gathering techniques used were questionnaires, interviews and observation.

The prototype of the motion based educational game was tested in a school in Norway where I had the opportunity of meeting the target population of the game, or a very similar one. There were in total 57 participants who study the sixth, third and second years of primary school. Afterwards, the data obtained during the game evaluation was analyzed and the findings were discussed in order to find suitable answers to the research questions established in this master's thesis. The findings indicate that the use of motion capture in educational games is especially effective to increase the motivation and engagement levels among children, and hence being able to communicate effectively the pedagogical message embedded in the game. Moreover, I was also able to detect that due to the motivation of the students towards the use of the motion based educational game, they were more inclined to learn about different topics in the game than in the classroom. Even though the interactions between the participants and the game were short and not all of them had the opportunity of playing all the game modes, there is a strong indication that motion based educational games are able to motivate and engage the players, however even if the results indicate that learning of the game concept was clear, there is need for more detailed studies in different game domains with different game concepts.

Regarding multiplayer capabilities in a motion based educational game, the findings point out that users prefer to play this kind of games when they are doing it alongside a peer. This preference of social gaming in comparison to experience the game as single player could be due to the extra challenges added when playing with or against others, and to the feeling of embarrassment that could arise when performing movements alone that could

appear awkward. Moreover, it was also detected that the players felt more motivated and engaged to play the game in one of the multiplayer modes than in the single player mode, however there is need to study the learning outcomes when comparing multiplayer and single player game modes.

I also spent some time finding which game concepts could be reused and how could they be exploited in order to work in a different learning domain. According to my findings and analysis, the game concepts that could be reused are tightly related to the arousal of the curiosity and challenge in the game presented in the form of the bonus items used, the difficulty levels and the multiplayer modes. Moreover, I also detected that as long as the educational game can also be categorized under the classification genre, the gestures and the idea of the conveyor band and pistons could be reused in different pedagogical domains with little effort.

Chapter 14

Future Work

The use of motion capture in educational games is a fairly unexplored area that needs to be researched more. The development of the game prototype in this master's thesis and its evaluation makes me think that there is a great opportunity for this kind of games because they are able to engage and motivate players through the use of innovative and interesting technology. With motion capture technology becoming cheaper it is possible that this kind of games become more readily available and used.

According to the experiences I collected through the game evaluation and the literature study performed, I find the next list of items interesting for future work in the game and the area of motion based educational games.

- Study the effects of motion capture in educational games in a different domain such as mathematics where more complex concepts take place.
- Study the role of motion capture in educational games with a different game concept, such as puzzles, platforms or any other that cannot be classified as a 'classification' game.
- Study the effects of motion based educational games in a long term basis.
- Analyze the use of high definition graphics and sounds in motion based educational games that could increment the curiosity of the players towards it.
- Investigate how to introduce this kind of games to the players in a more daily basis and not as a sporadic tool in an exhibition or in the classroom.
- Explore the use of network based multiplayer capabilities in motion based educational games.
- Compare the amount of data retained in a single player mode and one that offers multiplayer capabilities in the form of either cooperation or competitive gameplay.

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Part V

Appendix

Appendix A

Questionnaires

Here a copy of the questionnaire used for capturing the experiences of the participants of the game test can be seen. The questionnaire was done thinking that the participants would be young Norwegian students, hence the questions are written in their mother tongue and in a simple manner. Afterwards, the individual results are captured in an excel file.

Generell Informasjon

1. Jeg er en... <input type="radio"/> Gutt <input type="radio"/> Jente	2. Min klass er...
3. Jeg spiller dataspill... Aldri 1 2 3 4 5 Alltid	4. Jeg har spilt dataspill for å lære (f.eks lære seg å regne, skrive rett)... <input type="radio"/> Ja <input type="radio"/> Nei
5. Jeg har prøvd... <input type="checkbox"/> Wii Mote <input type="checkbox"/> PS Move <input type="checkbox"/> Kinect <input type="checkbox"/> Ingen	

Læring Konsepter

6. Jeg lærte å resirkulere ved å spille dataspillet... Uenig 1 2 3 4 5 Enig	7. Jeg synes det har blitt enklere å skille avfall etter å ha spilt dataspillet... Uenig 1 2 3 4 5 Enig
8. Jeg ville foretrekke å lære mer om resirkulering i... <input type="radio"/> Klasse <input type="radio"/> Dataspill	9. Jeg kommer til å resikulere hjemme etter å ha spilt dataspillet... Uenig 1 2 3 4 5 Enig

Morsomme Konsepter

10. Ved å spille et morsomt dataspill føler meg mer motivert til å lære...
Uenig 1 2 3 4 5 Enig

Motion Capture

11. Jeg synes at Kinect er morsommere for å spille enn mus og tastatur... Uenig 1 2 3 4 5 Enig	12. Jeg fikk lyst til å spille fordi jeg fikk å bruke Kinect.. Uenig 1 2 3 4 5 Enig
---------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------

Sosial Aspekt

13. Vanligvis spiller jeg dataspill som er... <input type="radio"/> Enkeltspiller <input type="radio"/> Flerspiller	14. Jeg spilte dette dataspillet i... <input type="checkbox"/> Enkeltspillermodus <input type="checkbox"/> Samarbeidsmodus <input type="checkbox"/> Versusmodus
---------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------

15. Dataspillmodusen jeg likte best var...

- Enkeltspiller
 Samarbeid
 Versus

Spillet Generell Informasjon

16. Mening med spillet var lett til å forstå... Uenig 1 2 3 4 5 Enig	17. Jeg synes det var enkelt å åpne menyene og bruke disse.. Uenig 1 2 3 4 5 Enig
18. Samhandling med dataspillet var god...	19. Jeg synes bevegelsene for å kontrollere spillet var lett å lære og utføre...

Uenig	1	2	3	4	5	Enig	Uenig	1	2	3	4	5	Enig
20. Jeg synes vanskelighetsgraden i starten var...							21. Jeg synes vanskelighetsgraden økte...						
Lett	1	2	3	4	5	Vanskelig	For Sakte	1	2	3	4	5	For Fort
22. Grafikken i dataspillet var...							23. Å se forskjellen på alle de forskjellige delene in dataspillet var...						
Dårlig	1	2	3	4	5	God	Lett	1	2	3	4	5	Vanskelig
24. Jeg synes lydene i dataspillet var...													
Dårlig	1	2	3	4	5	God							

Timestamp	Gender	Class	Game Exposure	Educational Game Exposure	Motion Capture Experience	Game Learning	Game Education Usefulness	Learning Preference	Game Usefulness Outside
5/25/2013 5:07:36	Gutt	6	3	Nei	Kinect	2		2 Dataspill	2
5/25/2013 5:21:17	Gutt	6	1	Ja	Wii Mote, Kinect	4		5 Klasse	1
5/25/2013 5:09:07	Gutt	6	4	Ja	PS Move	4		5 Klasse	3
5/25/2013 1:54:07	Gutt	2	2	Ja	Wii Mote	5		5 Dataspill	5
5/25/2013 2:01:06	Jente	2	5	Ja	Wii Mote	5		4 Dataspill	3
5/25/2013 2:02:40	Jente	2	3	Ja	Ingen	5		3 Dataspill	3
5/25/2013 2:04:30	Gutt	2	4	Ja	Wii Mote, PS Move	5		4 Klasse	5
5/25/2013 2:06:42	Jente	2	3	Ja	Ingen	5		4 Klasse	5
5/25/2013 2:08:10	Jente	3	2	Ja	Wii Mote	5		5 Dataspill	5
5/25/2013 2:54:13	Jente	6	1	Ja	Wii Mote	5		5 Dataspill	5
5/25/2013 3:21:43	Gutt	6	3	Ja	Wii Mote, PS Move	5		5 Dataspill	4
5/25/2013 3:25:15	Jente	6	5	Ja	Wii Mote, PS Move	3		3 Dataspill	4
5/25/2013 3:26:48	Jente	6	3	Ja	Wii Mote	3		3 Dataspill	5
5/25/2013 4:50:33	Jente	6	3	Ja	Wii Mote, Kinect	5		5 Klasse	5
5/25/2013 4:57:32	Jente	6	1	Ja	Ingen	5		5 Dataspill	5
5/25/2013 4:59:05	Jente	6	1	Ja	Wii Mote, Kinect	5		5 Dataspill	5
5/25/2013 1:56:14	Gutt	1	5	Ja	Wii Mote, Kinect	4		5 Dataspill	5
5/25/2013 1:58:25	Jente	2		Nei	Wii Mote	5		5 Klasse	5
5/25/2013 2:11:35	Jente	3	3	Nei	Wii Mote, PS Move	5		4 Dataspill	4
5/25/2013 2:18:55	Jente	3	3	Ja	Wii Mote, Kinect, PS Move	5		5 Dataspill	2
5/25/2013 2:21:00	Jente	3	2	Ja	Wii Mote	5		3 Dataspill	4
5/25/2013 3:23:21	Gutt	6	4	Ja	Wii Mote, PS Move	5		4 Dataspill	5
5/25/2013 4:32:00	Gutt	6	5	Ja	Wii Mote, PS Move	5		5 Klasse	5
5/25/2013 4:33:21	Gutt	6	2	Nei	Wii Mote	5		3 Dataspill	5
5/25/2013 4:36:39	Gutt	6	4	Ja	Wii Mote, Kinect, PS Move	5		5 Dataspill	5
5/25/2013 4:52:06	Gutt	6	3	Ja	Wii Mote, Kinect, PS Move	5		5 Dataspill	5
5/25/2013 4:53:36	Jente	6	3	Ja	Wii Mote	5		5 Dataspill	5
5/25/2013 4:55:16	Jente	6	3	Ja	Wii Mote, Kinect	5		5 Dataspill	3
5/25/2013 1:51:57	Gutt	2	3	Ja	Wii Mote, Kinect, PS Move	5		5 Dataspill	5
5/25/2013 2:13:18	Gutt	3	3	Ja	Wii Mote, Kinect	4		4 Dataspill	1

Game Motivation	Motion Capture Interest	Motion Capture Motivation	Social Preference	Exposure in the Game	Game Mode Preference	Game Goal Easiness	Menu Control Usability	Game Interaction	Ges Use
4	5	5	5	Enkeltspiller	Enkeltspillermodus	Enkeltspiller	5	5	5
3	5	5	5	Enkeltspiller	Enkeltspillermodus	Enkeltspiller	5	5	3
4	5	4	4	Flerspiller	Enkeltspillermodus	Enkeltspiller	5	5	3
5	1	1	1	Enkeltspiller	Versusmodus	Samarbeid	4	1	1
4	5	4	4	Enkeltspiller	Samarbeidsmodus	Samarbeid	3	5	4
4	5	3	3	Enkeltspiller	Samarbeidsmodus	Samarbeid	5	5	4
5	5	3	3	Enkeltspiller	Samarbeidsmodus	Samarbeid	3	2	3
4	5	5	5	Enkeltspiller	Samarbeidsmodus	Samarbeid	5	2	3
5	5	5	5	Enkeltspiller	Enkeltspillermodus	Samarbeid	5	3	5
5	3	5	5	Enkeltspiller	Versusmodus	Samarbeid	5	3	5
5	5	4	4	Enkeltspiller	Samarbeidsmodus	Samarbeid	5	5	4
5	3	1	1	Enkeltspiller	Samarbeidsmodus	Samarbeid	5	3	4
5	5	2	2	Enkeltspiller	Versusmodus	Samarbeid	5	3	5
5	5	5	5	Enkeltspiller	Samarbeidsmodus	Samarbeid	5	5	5
4	5	5	5	Enkeltspiller	Versusmodus	Samarbeid	4	2	3
4	5	5	5	Enkeltspiller	Versusmodus	Samarbeid	3	2	4
5	5	5	5	Flerspiller	Versusmodus	Samarbeid	4	4	1
1	5	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	2	1	1
5	5	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	5	4	5
5	5	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	4	2	4
5	5	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	3	2	4
5	3	5	5	Flerspiller	Versusmodus	Samarbeid	4	5	4
5	3	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	5	5	3
5	5	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	5	5	5
5	1	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	5	3	5
5	5	5	5	Flerspiller	Samarbeidsmodus	Samarbeid	5	5	5
5	5	3	3	Flerspiller	Versusmodus	Samarbeid	5	4	5
4	5	5	5	Flerspiller	Versusmodus	Samarbeid	4	4	4
5	5	4	4	Enkeltspiller	Samarbeidsmodus	Versus	5	2	5
3	5	5	5	Enkeltspiller	Samarbeidsmodus	Versus	4	2	3

Stores ability	Initial Difficulty	Difficulty Increase	Game Graphics	Game Elements Identification	Game Sounds
3	2	1	4	1	3
5	3	4	5	5	5
5	3	3	5	5	4
4	5	5	3	5	1
4	5	3	5	1	5
4	4	3	5	4	5
4	4	4	4	2	3
4	4	4	4	1	4
5	4	3	5	4	5
5	1	5	5	2	5
5	3	2	4	4	5
5	1	2	2	1	5
5	1	3	5	1	5
5	1	3	5	2	3
4	3	3	5	3	4
4	1	4	5	3	5
1	4	1	5	1	5
2	3	2	5	4	5
5	1	1	5	1	5
5	1	3	5	4	5
5	3	3	5	4	5
5	3	2	4	4	4
5	3	5	5	3	5
5	2	5	5	4	3
5	3	3	5	1	5
5	1	3	5	1	3
5	3	1	5	1	5
5	2	2	5	3	5
5	1	3	5	4	5
3	3	3	5	5	5

Timestamp	Gender	Class	Game Exposure	Educational Game Exposure	Motion Capture Experience	Game Learning	Game Education Usefulness	Learning Preference	Game Usefulness Outside
5/25/2013 2:14:59	Gutt	3	3 Ja		Wii Mote, Kinect, PS Move	5		5 Dataspill	4
5/25/2013 2:25:16	Jente	3	4 Ja		Wii Mote, PS Move	5		5 Dataspill	3
5/25/2013 2:55:50	Gutt	6	5 Ja		Kinect	5		5 Dataspill	5
5/25/2013 3:28:31	Gutt	6	5 Ja		Wii Mote, Kinect	5		5 Dataspill	5
5/25/2013 3:30:15	Gutt	6	4 Ja		Wii Mote, Kinect, PS Move	3		5 Klasse	4
5/25/2013 3:31:51	Gutt	6	3 Ja		Wii Mote, Kinect, PS Move	2		4 Klasse	4
5/25/2013 4:34:59	Gutt	6	5 Ja		Wii Mote, PS Move	5		Dataspill	1
5/25/2013 4:49:15	Gutt	6	4 Ja		Wii Mote, PS Move	5		5 Dataspill	5
5/25/2013 5:02:24	Gutt	6	3 Nei		Wii Mote	4		4 Dataspill	3
5/25/2013 1:46:15	Gutt	2	3 Ja		Wii Mote, PS Move	5		4 Dataspill	5
5/25/2013 1:49:34	Gutt	2	3 Ja		Wii Mote, Kinect, PS Move	5		5 Dataspill	3
5/25/2013 2:09:53	Jente	3	4 Nei		Wii Mote	5		4 Dataspill	4
5/25/2013 2:23:21	Jente	3	4 Ja		Wii Mote, Kinect, PS Move	5		5 Dataspill	3
5/25/2013 4:38:13	Gutt	6	4 Ja		Wii Mote	5		5 Dataspill	5
5/25/2013 4:39:58	Gutt	6	4 Ja		Wii Mote	5		5 Dataspill	3
5/25/2013 4:47:54	Gutt	6	3 Ja		Wii Mote	5		5 Dataspill	4
5/25/2013 5:00:35	Jente	6	2 Ja		Wii Mote	5		5 Dataspill	3
5/25/2013 5:04:02	Jente	6	3 Ja		Wii Mote, Kinect, PS Move	3		2 Dataspill	3
5/25/2013 5:05:59	Jente	6	4 Ja		Wii Mote, Kinect	2		1 Dataspill	1
5/25/2013 5:10:31	Jente	6	Ja		Wii Mote	5		3 Dataspill	5
5/25/2013 5:12:04	Jente	6	2 Ja		Wii Mote	4		5 Dataspill	5
5/25/2013 5:15:32	Jente	6	2 Ja		Wii Mote	5		4 Dataspill	3
5/25/2013 5:17:34	Gutt	6	4 Ja		Wii Mote, Kinect, PS Move	5		4 Dataspill	3
5/25/2013 5:19:31	Gutt	6	4 Ja		Wii Mote, PS Move	5		5 Dataspill	5
5/25/2013 5:22:58	Jente	6	2 Ja		Wii Mote, PS Move	5		5 Dataspill	5
5/25/2013 5:13:56	Jente	6	2 Nei		Wii Mote, Kinect, PS Move	5		5 Dataspill	4
5/25/2013 5:24:27	Jente	6	1 Ja		Wii Mote, Kinect, PS Move	2		1 Klasse	2

Game Motivation	Motion Capture Interest	Motion Capture Motivation	Social Preference	Exposure in the Game	Game Mode Preference	Game Goal Easiness	Menu Control Usability	Game Interaction	Ges Use
4	5	4	Enkeltspiller	Samarbeidsmodus, Versusmodus	Versus	5	2	3	
5	5	5	Enkeltspiller	Samarbeidsmodus	Versus	4	4	3	
5	3	5	Enkeltspiller	Samarbeidsmodus, Versusmodus	Versus	5	5	5	
5	5	4	Enkeltspiller	Samarbeidsmodus	Versus	5	5	5	
5	5	5	Enkeltspiller	Samarbeidsmodus	Versus	5	4	3	
5	5	5	Enkeltspiller	Samarbeidsmodus	Versus	5	3	3	
5	2	1	Enkeltspiller	Samarbeidsmodus	Versus	5	1	5	
5	5	5	Enkeltspiller	Enkeltspillermodus	Versus	5	3	4	
2	5	3	Enkeltspiller	Versusmodus	Versus	4	5	4	
3	3	4	Flerspiller	Enkeltspillermodus	Versus	3	2	3	
5	5	5	Flerspiller	Samarbeidsmodus	Versus	5	2	5	
5	5	5	Flerspiller	Samarbeidsmodus, Versusmodus	Versus	5	4	3	
5	5	5	Flerspiller	Samarbeidsmodus	Versus	4	4	4	
5	1	5	Flerspiller	Samarbeidsmodus	Versus	5	4	5	
5	4	5	Flerspiller	Samarbeidsmodus	Versus	3	4	3	
5	5	3	Flerspiller	Samarbeidsmodus	Versus	3	3	3	
5	5	5	Flerspiller	Versusmodus	Versus	5	4	4	
3	5	5	Flerspiller	Versusmodus	Versus	5	4	4	
5	5	5	Flerspiller	Versusmodus	Versus	4	3	2	
5	5	4	Flerspiller	Samarbeidsmodus	Versus	4	5	3	
4	5	4	Flerspiller	Samarbeidsmodus	Versus	5	3	4	
5	5	5	Enkeltspiller	Enkeltspillermodus		3	3	5	
5	3	5	Enkeltspiller	Enkeltspillermodus		4	5	5	
5	5	5	Enkeltspiller	Enkeltspillermodus		5	4	4	
5	5	5	Enkeltspiller	Enkeltspillermodus		5	5	5	
5	5	5	Flerspiller	Enkeltspillermodus		5	5	4	
5	5	5	Flerspiller	Enkeltspillermodus		5	5	4	

Stores ability	Initial Difficulty	Difficulty Increase	Game Graphics	Game Elements Identification	Game Sounds
5	3	5	5	5	5
3	3	3	5	3	5
5	1	1	5	1	5
5	3	3	5	1	5
5	1	4	5	3	5
5	1	3	5	3	5
3	1	4	1	5	2
4	1	3	5	4	5
5	1	3	5	3	4
5	3	3	5	5	5
5	1	3	5	1	5
5	1	3	5	1	5
4	3	3	5	3	5
5	3	3	5	5	5
3	3	3	5	2	5
2	3	3	5	3	5
5	3	3	4	1	5
5	4	3	4	3	4
4	3	3	5	1	5
4	3	3	4	3	3
5	2	3	4	4	4
3	3	4	5	3	5
5	4	2	5	5	5
5	1	2	3	4	3
5	3	2	5	1	5
5	4	3	5	3	5
5	3	3	5	5	2

Appendix B

Interview

B.1 Interview Questions

The interview was performed to some selected participants. The interviews were conducted in Norwegian, however the questions contain the same information as the translated version in this section.

Learning Preference

1. What do you think is good about learning in a game?

Fun Concepts

2. Which parts in the game made it fun for you?
3. What would you change in the game to make it more fun?

Game Reusability

4. What other things you think could be learned with this game?

Motion Capture

5. What do you think about using Kinect in the game?

Social Aspect

6. Which game mode did you like the best and why?

General Information

7. General comments you have about the game.

B.2 Transcript Interview One

Intervjuer: Ja, eh hva er bra med å lære fra dataspill. Eller hva synes du er bra i forhold til det?

Svarer 1: Ehh liksom, hva som er bra på en måte, bra å lære mener du det?

Intervjuer: Ja, eller hva kan være positivt med å lære fra dataspill.

Svarer 1: Litt morsommere måte å lære ting på enn å bare høre på undervisning.

Intervjuer: Har du no...?

Svarer 2: Ja, det er mye morsommere og så synes jeg det er regelmessig enklere å huske ting når det er morsommere.

Intervjuer: Mm ja.

Svarer 1: Lettere å huske ja.

Intervjuer: Bra, ehh. Hvilke ting i det spillet her synes dere var morsomt?

Svarer 1: Det at det gikk ann å lære noe nyttig av det i tillegg til at det var artig.

Svarer 2: Ehh.. akkurat det samme.

Intervjuer: Du har ikke noe å tilføre eller? Nei. Hva ville dere ha forandret for å gjøre spillet enda mer morsomt da?

Svarer 1: Eh kanskje hatt noe litt enklere kontroller for det var litt sånn, man vridd hånda...

Svarer 2: (Avbryter) jeg synes det var morsomt jeg.

Svarer 1: Plutselig satte jeg den på pause.

Intervjuer: Mm, men du synes det var morsomt sånn som det var?

Svarer 2: Jeg synes det var morsomt at du måtte liksom bevege på deg for å få det til det var litt uvant men det var veldig morsomt.

Intervjuer: Hvilke andre ting ville dere forandre for å gjøre det enda bedre eller morsommere?

Svarer 1: Kanskje fiksa grafikken liksom så det ikke var noe som akselererte, enklere å se.

Intervjuer: Mm.. ehmm.. hva slags ting tror dere at dere har lært i dette spillet? Eller andre ting dere tror det går ann å lære, ikke bare resirkulering. Tror dere det går ann å lære andre ting, på en måte, med sånn type spill?

Svarer 1: Dem fleste fag, på en måte.

Intervjuer: Ja, hvordan ser dere får dere at det kunne vært brukt det herre greiene her for å lære andre fag da?

Svarer 1: Ehm, hvis for eksempel det hadde vært det samme, men det hadde vært med matte. for eksempel, så har det stått, for eksempel, fem ganger, ett eller anna, og så har det vært en boks der svarene hadde stått og så bare gjort akkurat det samme og dytta stykket oppi kassen.

Intervjuer: Mm. Har du noen andre ideer?

Svarer 2: Ja, vi kunne for eksempel, hvis man skulle lære seg om forskjellige land og sånt, så kunne man for eksempel ha flagg av landa og så holde på å dytte dem oppi.

Intervjuer: Ja, bra. Eh, hva synes dere med å bruke sånn kinect, sånn kamera, i dataspill generelt?

Svarer 1: Eh jeg synes det er ganske morsomt når man kan røre seg i stedet for å sitte og trykke på taster eller holde på med kontroll.

Intervjuer: Mm. Hva synes du?

Svarer 2: Ehmm. Egentlig mye morsommere enn å sitte med en kontroll.

Intervjuer: Mm, ehh.. hvilket spillmodus likte dere best?

Svarer 1: Jeg ville kanskje si samarbeidsmodusene, fordi jeg har stort konkurranseinstinkt fordi det blir trist når jeg vinner fordi jeg er en dårlig taper.

(Latter)

Intervjuer: Hva synes du?

Svarer 2: Nei jeg likte egentlig begge to like godt jeg.

Intervjuer: Mm hva er fordelene med de forskjellige modusene da?

Svarer 1: Ehh med samarbeid så er det jo at du lærer jo å samarbeide, på en måte. Du må prøve å finne ut best mulig måte å gjøre det på. Og med den (uforståelig) med vind og sånn (latter) .

Intervjuer: Ehhh få se.. Hvordan synes dere det var å spille spillet, sånn generelt?

Svarer 1: Det var ganske morsomt så var det gøy at det var resirkulering da, for det er noe som kan være godt å vite noe om. For det er ikke alle som vet hva som skal hvor.

Svarer 2: Det var veldig morsomt og et nyttig spill, på en måte. Ikke bare sånn skyting og.. Det var litt mer sånn nyttige ting. Bare lære på en annen måte.

Intervjuer: Ja, så bra. Er det noe annet dere vil si i forhold til spillet, til slutt?

Svarer 1: Eh er ikke sikker.

Svarer 2: Jeg tror ikke det.

Intervjuer: Nei. Takk.

B.3 Transcript Interview Two

Intervjuer: Hmm. Jo... hva synes dere det er bra med å lære fra dataspill. Er det noe som er positivt med det?

Svarer 3: Ehh.

Svarer 4: Vi lærer på en morsom måte.

Svarer 3: Ja, det gjør vi. Og trenger ikke å i stedet for at vi skal lære fra en bok så trenger vi ikke å kjede oss. Hvis dem synes det er kjedelig.

Intervjuer: Er det noen andre ting dere synes er bra med å lære fra dataspill?

Svarer 3: Ehm at man har det gøy samtidig som man blir smartere.

(Latter)

Intervjuer: Ehh hva synes dere var morsomme ting med dette resirkuleringsspillet som dere spilte?

Svarer 3: Ehh at det gikk fortere.

Svarer 4: Ja, at man var i starten, det var ganske enkelt, og så gikk det bare fortere og fortere og da måtte man konsentrere seg.

Svarer 3: Mm.

Intervjuer: Andre ting som var morsomt?

Svarer 3: Det var morsomt hva tingene var. Så man måtte prøve å finne ut selv om det var plastikk eller hva det var.

Intervjuer: Hva ville dere forandra på spillet så det hadde blitt enda morsommere?

Svarer 3: Ehh at det kanskje hadde vært ehghhm... litt flere ting som hadde kommet oftere.

Svarer 4: Mm.

Intervjuer: Flere ting å resirkulere?

Svarer 3 og Svarer 4: Mm.

Svarer 3: At det hadde kommet litt oftere.

Intervjuer: Er det andre ting som dere tenker på som kunne vært morsomt på spillet?

Svarer 3: Hmm vet ikke.

Svarer 4: Ikke jeg heller.

Intervjuer: Tror dere det hadde gått ann å lære andre ting enn resirkulering i et sånt spill?

Svarer 3: At det er lurt å resirkulere?

Intervjuer: Nå tenkte jeg på andre ting enn resirkulering. Hadde det gått ann å bruke på andre fag som geografi eller matte?

Svarer 3: Det kunne jo ha gått ann for eksempel i, hvis man skal lære seg land, byer i land for eksempel. Så kunne det ha kommet ned noen navn på byer og så kunne vært (uforståelig).

Intervjuer: Er det andre ting det kunne gått ann å lært?

Svarer 4: Matte? Det kunne...og...ja.

Intervjuer: Mm. Hvordan synes dere det var å bruke sånn kinect kamera i spill da synes dere det er bra eller?

Svarer 3: Ja, det er kjempegøy.

Svarer 4: Ja, for da må vi røre på oss samtidig som vi tenker.

Intervjuer: Hvordan spillmodus likte dere best når dere prøvde versus og samarbeid? Hva synes dere var morsomst?

Svarer 3: Hmm oi... som i, vanskelig å velge.

Svarer 4: Versus tror jeg.

Intervjuer: Mot hverandre?

Svarer 4: Ja.

Svarer 3: Jeg likte begge to ganske godt, men versus tror jeg var bra.

Svarer 4: Er så konkurranse mennesker.

Svarer 3: Ja.

(Latter)

Intervjuer: Men hvorfor likte dere det best da?

Svarer 3: Vi konkurrerte mot hverandre.

Intervjuer: Ja. For å se hvem som vant?

Svarer 3 og Svarer 4: Ja (latter).

Intervjuer: Hva synes dere var morsomt med samarbeidsmoduset?

Svarer 3: Eh det var jo på en måte litt morsomt for hvis hun tok en av mine ting, da var det liksom "neiiiiiii". Så vi måtte passe på at vi ikke tok hverandre sine ting. Det var litt gøy.

Intervjuer: Ja. Ehhmmm hvordan synes dere det var å spille dette spillet her da?

Svarer 3: Det var gøy.

Svarer 4: Mm det var veldig gøy.

Svarer 3: Og det var lærerikt.

Intervjuer: Mm, er det noe mer dere ønsker å legge til med tanke på spillet?

Svarer 3: Nei.

Svarer 4: Nei.

Svarer 3: Det var ganske bra.

Intervjuer: Supert, takk skal dere ha!

B.4 Transcript Interview Three

Intervjuer: Ehm, hva synes dere er bra med å lære fra dataspill. Har dere noe dere synes er bra i forhold til det?

Svarer 5: Ehh ...

Intervjuer: Er det noe positivt med det?, på en måte, å lære fra dataspill.

Svarer 5: Ja, det er noe positivt å lære noe hvertfall.

Svarer 6: Noen spill, som bilsimulator det er drit kult.

Intervjuer: Hva kan du lære av det da?

Svarer 6: Kjøre bil.

Intervjuer: Hva var det som var morstomt med det resirkuleringsspillet synes du?

Svarer 5: At du bruker kinect og henda og sånn. Ja.

Intervjuer: Var det noe du synes var morsomt med spillet?

Svarer 6: Hmm du lærer hva som er resirkulering og papir og sånt.

Intervjuer: Er det noe dere skulle ønske dere kunne forandret i spillet for å gjøre det enda morsommere?

Svarer 5: Hmm.. Jeg er ikke helt sikker.

Svarer 6: Ikke jeg heller.

Intervjuer: Skal vi se. Tror dere det går ann å bruke et sånt type spill til å lære andre fag enn resirkulerer, er det andre ting det går ann å lære og sånn?

Svarer 5: Ja matte? For eksempel.

Intervjuer: Hvordan kunne man gjort det?

Svarer 5: Liksom mange svar og sånn kommer det noen pluss stykker eller noe.

Intervjuer: Ja. Er det noe annet ag man kunne brukt det til?

Svarer 5: Hmm norsk.

Svarer 6: Norsk.

Svarer 5: Liksom substantiv, adjektiv, verb og sånn. Og så kommer dem ut.

Intervjuer: Bra. Ehm hvordan synes det er å bruke sånn kinect på sånn dataspill og sånn og det kameraet.

Svarer 5: Sikkert kult.

Svarer 6: Ja, det var det.

Svarer 5: Det var morsomt.

Intervjuer: Hvilket spillmodus likte dere best?

Svarer 5: Ehmm, samarbeidsmodus...

Svarer 6: Samarbeidsmodus.

Svarer 5: Tror jeg.

Intervjuer: Hvorfor synes dere at det var morsomts da?

Svarer 5: Fordi...

Svarer 6: Da kan du gjøre en ting i stedet for begge.

Svarer 5: Ja. Fordi det er litt vanskelig med begge to.

Intervjuer: Hva synes dere om den versus modusen da? Spille mot hverandre.

Svarer 6: Det var kanskje bra.

Svarer 5: Det var ganske morsomt det å. Men det var litt vanskelig.

Svarer 6: Det var litt krevende.

Intervjuer: Ja, det var lit vanskeligere ja. Ehmm.. Hvordan synes dere det var å spille dette spillet da?

Svarer 5: Jo, det var morsomt det.

Svarer 6: Morsomt. Kults.

Intervjuer: Ja.

Svarer 6: Lærende.

Intervjuer: Er det noe som dere kunne tenkt dere å gjort, å spille flere sånne spill i, på en måte, i fag og, klasser og?

Svarer 5: Hæ?

Intervjuer: At dere kunne tenkt dere å ha flere sånn spill som dere kunne brukt på skolen?

Svarer 5: Ja.

Intervjuer: Yes. Takk skal dere ha.

B.5 Transcript Interview Four

Intervjuer: Ehm. Hva er bra med å lære fra dataspill, eller hva synes dere er positivt med å lære fra dataspill?

Svarer 7: Ehmm.. Hvis det er sånn læredataspill så synes jeg det egentlig er morsomt å spill og så lærer man noe nytt. Så man ikke bare hører på noen mennesker som snakker om det.

Svarer 8: Jeg er faktisk enig i det der. Men det er letteste å lære seg ting er å utføre det som i for eksempel spill da. Enn at du sitter i en bok og skriver.

Intervjuer: Hva synes dere er morsomt i det resirkuleringspillet?

Svarer 7: Ehh at man liksom gjør sånn med hendene i stedet for å sitte på dataen.

Intervjuer: Mm, andre ting?

Svarer 8: Ja at vi kunne på en måte samarbeide og at man kunne på en måte prøve å få de andre.

Svarer 7: Ja, man kunne velge.

Intervjuer: Mm. Hva ville dere forandret på for å få spillet ennå morsommere?

Svarer 8: Jeg vet ikke jeg.

Svarer 7: Ehh kanskje hadde.. hehe. Litt flere ting som for eksempel vannmelon, frukt, gammel vannmelon. Ooogg sånn forskjellig. Og litt mer bonusting. Så gjør det vanskeligere for motstanderen.

Intervjuer: Ehm, tror dere det hadde gått ann å bruke dette spillet til å lære andre ting, i andre fag for eksempel?

Svarer 7 og Svarer 8: Ja!

Intervjuer: For eksempel?

Svarer 7: Kanskje sånn med for eksempel sånn (uforståelig) Sånn hva kommer fra Egypt og.. jeg husker ikke hva faget heter, men et fag der vi lærer om Jesus. Om kristendommen. Du kan kanskje ta Jesus på en side og andre ting på en annen side.

Intervjuer: Ja (uforståelig). Hva synes dere om å bruke kinect i det dataspillet da?

Svarer 7: Det synes jeg var veldig genialt.

Svarer 8: Det synes jeg også.

Intervjuer: Hvilket spillmodus likte dere best og hvorfor?

Svarer 7: Versus, da kan man på en måte slå den andre hvis man sier at jeg skal grus deg så sier den andre, det klarer du ikke likevel. Så vinner den som sier at det klarer du ikke likevel.

Intervjuer: Mm, hva synes du?

Svarer 8: Ehm.. det er egentlig...jeg synes det var morsomt sånn samarbeid for da var det litt enklere å se hva det var og da er det liksom ikke så veldig... så du slipper at når det går fort da så blir det litt morsommere enn når det er en så det ikke blir sånn “men hvor er den”.

Intervjuer: Mm, bra. Ehm.. hva synes dere generelt om å spille det her spillet her? Hvordan var det å spille det?

Svarer 7: Ehh...

Svarer 8: Det var morsomt.

Svarer 8: Very funny.

(Latter)

Intervjuer: Yes, har dere noen andre kommentarer til spillet?

Svarer 7: Ehh...

Svarer 8: Egentlig ikke.

Svarer 7: Egentlig ikke jeg heller.

Appendix C

Requirements

This chapter contains the requirements identified in the last prototype iteration and that continue to exist in the current game prototype. The requirements are separated according to the screen in which they are relevant.

C.1 Codes in the Requirements

In order to facilitate tracking and identification of the requirements I decided to use a series of codes that would make the identification of the requirements simpler for the developer and other stakeholders.

- GC: General Characteristics, refers to those characteristics that are common for all parts of the system.
- MS: functionality of the Main Screen.
- GP: functionality part of the gameplay in any of its modus.
- PS: functionality of the Pause Screen.
- SS: functionality of the Save Score Screen.
- HS: functionality of the High Scores Screen.
- GO: Functionality of the Game Over Screen.
- WS: Functionality of the Waiting Screen.
- OS: Functionality of the Options Screen.
- NF: refers to non-functional requirements.
- IS: refers to the functionality on the Instructions Screen.

C.2 General Characteristics

ID	Name	Description	Priority
GC01	Start the Game	The game shall start and provide an interface for the player.	H
GC02	Close the Game	The main menu shall be closed at any desired time by the user.	H

Table C.1: General characteristics requirements.

C.3 Main Menu Screen

ID	Name	Description	Priority
MS01	Arcade Mode	The main menu shall provide an option to play in Arcade Mode.	M
MS02	High Scores	The main menu shall provide an option to view the current highest scores.	L
MS03	Exit Game	The main menu shall provide an option to exit the game.	L
MS04	Menu Navigation	The main menu shall be controlled through the use of the navigation actions.	M

Table C.2: Main menu screen requirements.

C.4 Pause Screen

ID	Name	Description	Priority
PS01	Return to Game	The pause screen shall provide an option to return to gameplay.	M
PS02	Exit Game	The pause screen shall provide an option to exit the game.	M
PS03	Navigation	The pause screen shall be controlled with the navigation actions.	M

Table C.3: Pause Screen requirements.

C.5 Gameplay

ID	Name	Description	Priority
GP01	Game Information	The game shall display the game session information.	M
GP02	Conveyor Band	The game shall have an animated conveyor band in the center of the screen.	H
GP03	Recyclable Items	The game shall generate items randomly that travel through the conveyor band.	H
GP04	Bonus Items	The game shall generate bonus items that travel through the conveyor band. The probability of apparition is 10%.	H
GP05	Pistons	The game shall place the pistons at the side of the conveyor band.	H
GP06	Pistons Activation	The game shall animate the pistons when the player performs a swipe action.	H
GP07	Item Recycling	The game shall recycle an items if an activated piston collides with an item.	H
GP08	Earn Points	The game shall give 10 points to the player if the recycled item was correct.	H
GP09	Lose Credit	The game shall subtract 1 credit to the player if the recycled item was incorrect.	H
GP10	Activate Bonus	The game shall activate a bonus item if there is one on the band and the accept action was detected.	M
GP11	Extra Credit	The game shall add 1 credit to the player when the extra credit bonus item is activated.	M
GP12	Slow Down	The game shall reduce the speed of the items and conveyor if the slow down bonus item is activated.	M
GP13	Double Points	The game shall double the amount of points earned for recycling items for 15 seconds after the double points bonus item has been activated.	M
GP14	Increase Speed	The game shall increase the speed of the items that travel through the band every 50 points.	M
GP15	Game Pause	The game shall go the the pause screen every time the pause action is performed.	L
GP16	Game Over	The game shall go to the game over screen whenever the player loses all his credits.	H

Table C.4: Gameplay requirements.

C.6 High Scores Screen

ID	Name	Description	Priority
HS01	High Scores	The screen shall show the top 10 scores in the game.	L
HS02	Exit Screen	The screen shall exit on cancel action.	L

Table C.5: View high scores requirements.

C.7 Save Score Screen

ID	Name	Description	Priority
SS01	Show Alphabet	The save score screen shall have an alphabet menu.	M
SS02	High Scores	The save score screen shall show the top 10 scores in the game.	L
SS03	Player's Score	The save score screen shall show the player's score.	L
SS04	Navigation	The screens shall be done with the navigation actions.	M
SS05	Name	The player's name shall have a maximum of 20 characters.	L
SS06	Save Score	The screen shall save into the DB the player's information.	M
SS07	Ranking	The save score screen shall display the player's ranking.	M
SS08	Exit Screen	The screen shall transition to the main menu 5 seconds after the score has been saved.	M

Table C.6: Save score requirements.

C.8 Non-Functional Requirements

ID	Name	Description	Priority
NF01	Platform	The game shall be developed for windows based computers.	H
NF02	Framework	The game shall be developed using the XNA Framework.	H
NF03	Programming Language	The game shall be developed using C#.	M
NF04	Motion Capture	The game shall use Microsoft's Kinect for the interaction.	H
NF05	Modularity	The game shall be designed with high modularity.	H
NF06	Screen Management	The game shall use Microsoft's screen management examples already in use in Cyberlab.	M
NF07	Database	The game shall make use of the database manipulation code used already in Cyberlab.	M
NF08	Configuration	The game shall be able to be configured through an XML file where the game elements and art can be specified.	M

Table C.7: Non-functional requirements.

Appendix D

Game Architecture Views

In this chapter I present more detailed software architecture views that contain information regarding their methods and variables.

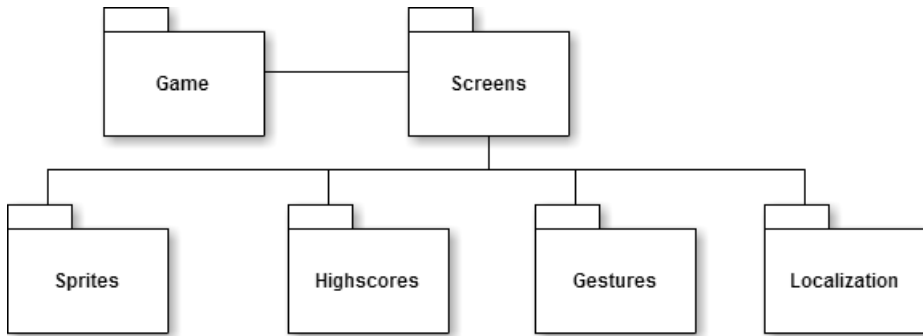
D.1 Game Architecture Coding Key

Since some of code has been reused from Microsoft's and Cyberlab works I created a color notation in order to make difference with the modules used. It is important to note that I only provide a description of those modules developed or modified by me.

- Orange: These modules are created by Microsoft. They are related to the screen management in the game which was a constraint established by Cyberlab.
- Purple: These modules have been previously coded by Cyberlab. They deal with the gesture recognition and database manipulation.
- Aqua: These modules are developed by me and are present through the different subsystems.
- Yellow: These modules originally from Microsoft but they have been heavily modified by me in order to adapt them to the game.
- Blue: The modules are originally from Cyberlab but I have modified them in order to add the functionality needed by the game.

D.2 Game Logic Views

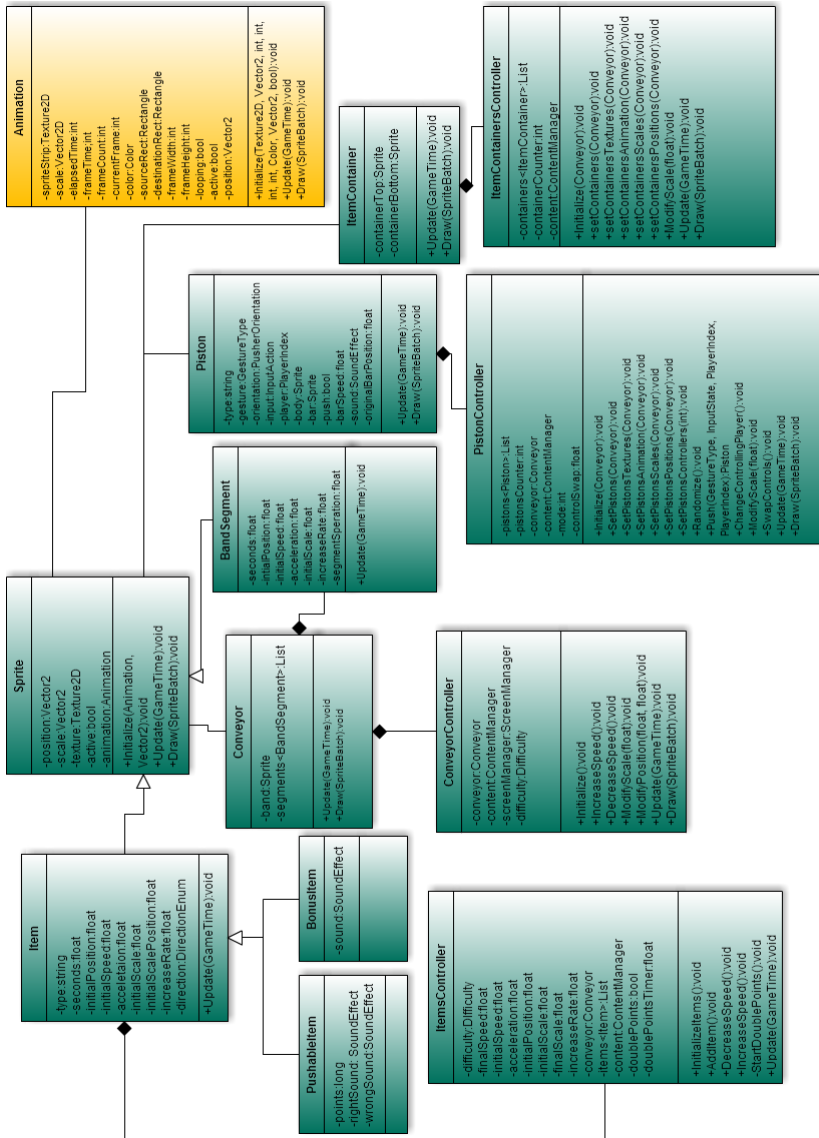
The logic view has been separated into subsystems because otherwise it would have not been possible to show it in a single picture.



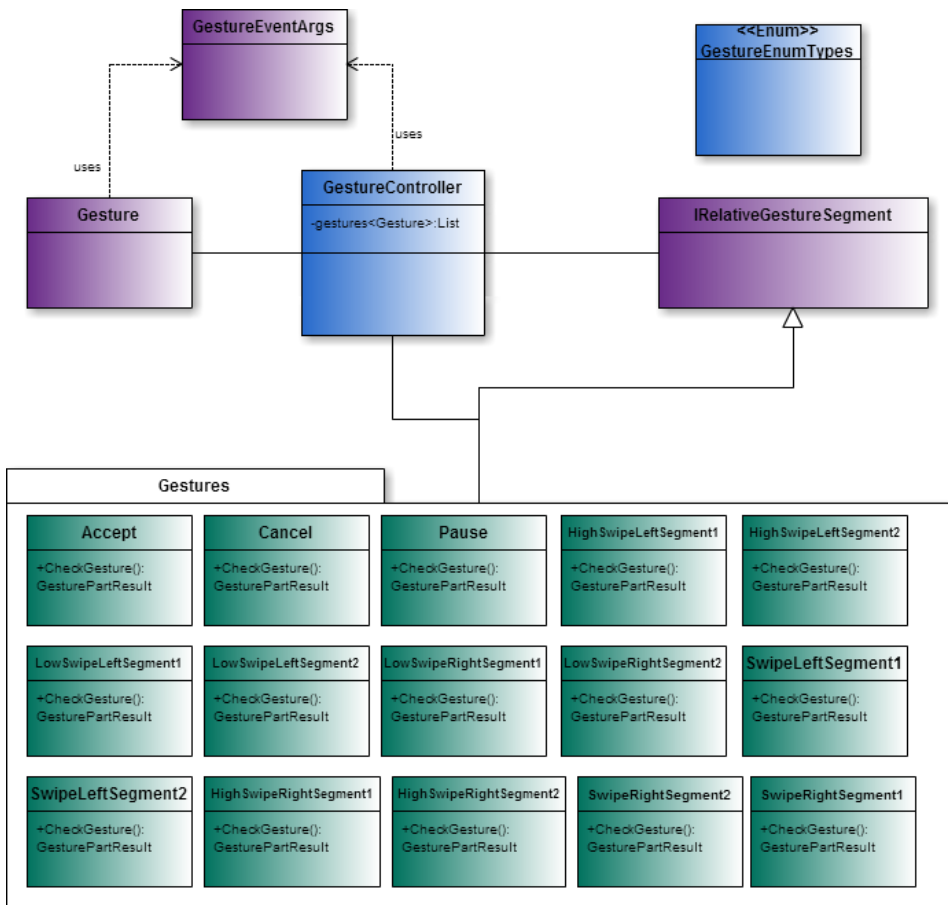
D.2.1 Game Subsystem



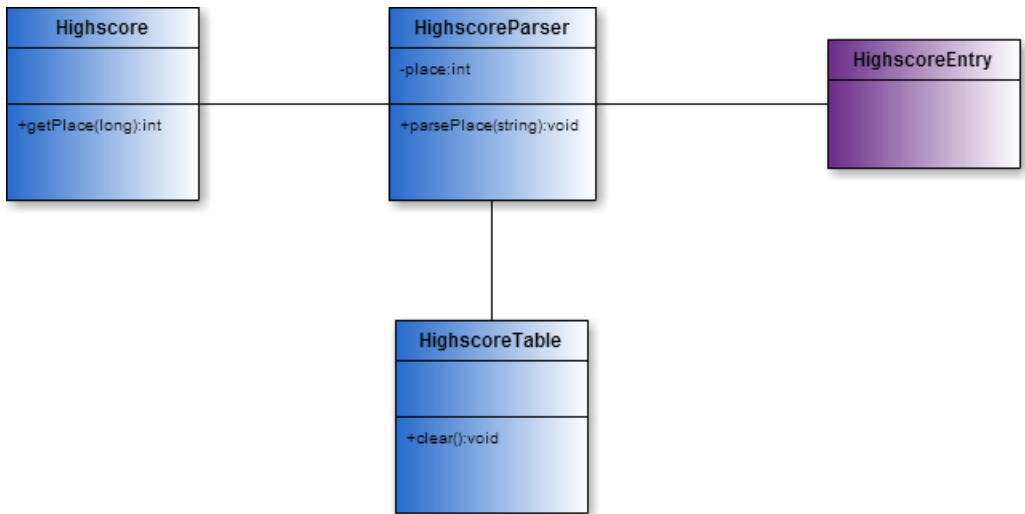
D.2.3 Sprites Subsystem



D.2.4 Gestures Subsystem



D.2.5 High Scores Subsystem



D.2.6 Localization Subsystem

