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Serious Games

Player-Centered Game Design and the Theory of Multiple Intelligences

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List of abbreviations

Abbreviation	Meaning
MI	Multiple Intelligences
MIPQ	Multiple Intelligences Profiling Questionnaire
GEQ	Game Experience Questionnaire
GE	Game Experience
ITS	Intelligent Tutoring System
ALE	Adaptive Learning Environments
PRE	Pedagogical Recommender Systems
SG	Serious Games

Abstract

In this thesis the potential for a player-centered game design method for serious games is analyzed on the basis of an experiment, relating game experience and gameplay behavior to theory of Multiple Intelligences (MI). Results indicate that MI profiles can be applied as player typologies. These player typologies have effects on gameplay experience outcomes. Differences in gameplay experience are important because they have a strong relation to the learning potentials of serious games.

1

Introduction

- Context
- Previous Research
- Problem Statement
- Research Question
- Experiment
- Relevance
- Thesis Structure

In the first chapter serious games, player-centered game design, and the theory of Multiple Intelligences (MI) are introduced. A brief overview is presented of preceding research on the Maze Commander game. The problem statement is presented, the experiment based on the developed Maze Balancer game is introduced, and the research question, motivation and overall thesis structure are presented.

1.1 Context

Serious games

As game developers, enterprises, and educators discovered the learning potential of games, so-called serious games are slowly being adopted in educational practices. A serious game differentiates itself from other games by having a primary purpose other than entertainment. In practice this often means that the purpose of a serious game is to teach or train the player. Serious games offer great opportunities for educational reform, and have been applied in many domains. Problem solving is often central to games, and in serious games it is used to teach players about specific domain issues, but even games that are not considered "serious" can have significant learning outcomes (Gee, Learning and Games., 2008). Game designers have been very successful at teaching all kinds of individuals how to play their games (Becker, 2005). Problem solving is the core activity players engage in when they play games. Games present a sequence of problems to the player, which will be referred to as the game content. Whether the game content is considered acceptable or not from an educational perspective, players have to learn and overcome the challenges that are presented to them. Some argue that serious games have not been widely accepted yet, because the justification for using games for educational purposes is still unknown to many. Others argue it is because of the lack of immersive gameplay in many serious games compared to popular AAA-games.

Player-centered game design

Games often involve complex user interactions, and interaction modes widely differ from game to game. This is why case-specific information is required to make informed decisions in the design process. Player-centered game design, similar to user-centered software design, is a design method in which player-specific information is used to make informed decisions in the design process. Player modeling can be applied to differentiate between different player types. Unfortunately current differentiation between player types often tends towards overly simplistic categorizations (Charles, et al., 2005), e.g. casual and expert players. But many other player characteristics could be used to differentiate between players, especially in the case of serious games. The question is which player characteristics are relevant and useful to consider. Since the primary purpose of serious games is related to education, modeling players based on learning characteristics could provide a relevant way to differentiate between player types.

Multiple intelligences

There are several popular theories that cover learning differences among people. The experiment executed for this master thesis identifies learning differences by evaluating the players' multiple intelligence profiles (Gardner, Frames of mind: The theory of multiple intelligences., 1983). The theory of Multiple Intelligences (MI) identifies several unique intelligences, called intelligence dimensions, and states that each individual possesses all intelligence dimensions, though with varying strengths. An intelligence dimension, as defined by Gardner, is the ability to deal more easily with a specific type of content. To explore player modeling possibilities based on the intelligence dimensions identified by the MI theory, relations must be found between the intelligence dimensions, game features and game experience results.

1.2 Previous Research

This master thesis is a follow up study. The preceding series of studies were focused on the relation of multiple intelligences to the interaction modality in games. The game that was developed for these experiments was called Maze Commander (Sajjadi, Gutierrez, Trullemans, & Troyer, 2014). Some of the experiments relating to Maze Commander will be mentioned briefly.

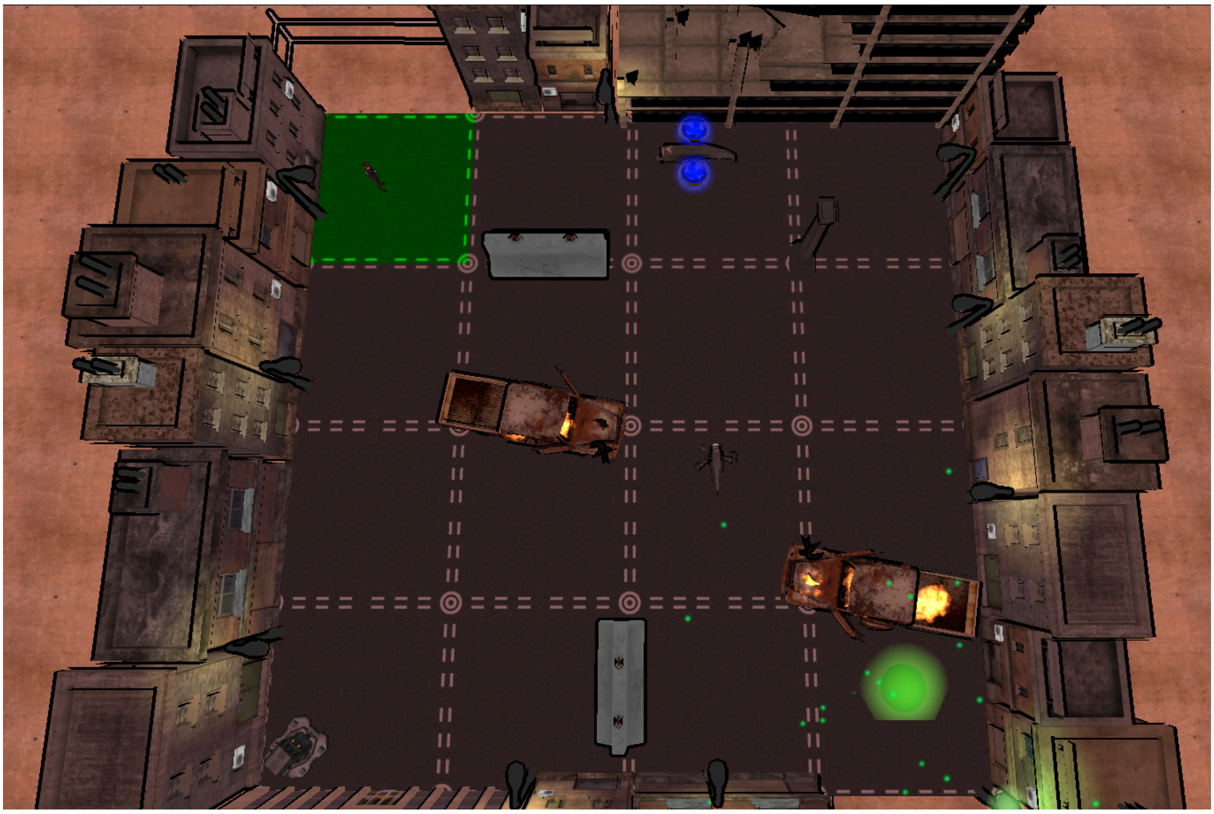


Figure 1 Maze Commander

Maze commander

The first study was focused on the relation between player communication and interaction modality. In this study two players were asked to escape from a maze by collaborating. Each player used a different interaction modality. One player was viewing the maze through an Oculus Rift (see figure 1) but could not control the character in the maze, while the other player could not see the maze but was able to control the character by using Sifteo Cubes (www.sifteo.com). Results showed no significant differences in game experience between the two modes of interaction. However in this study no differentiation was made between different player types, such as differences in learning styles, which could relate to the modality preference.

The second study was focused on the preference for an interaction modality. The players were profiled using the Multiple Intelligence Profiling Questionnaire. The two players were asked to play the game with both modalities in two different game sessions. Afterwards they were asked which modality they preferred. Results showed that there was no significant correlation between players' intelligences and their preference for an interaction modality.

1.3 Problem Statement

Novel modalities such as gesture-based interactions, offer new possibilities for the development of serious games, however there is little research investigating the effect of these modalities on game experience. As mentioned in the research on Maze Commander:

"Work that investigated the effect of interaction modes or controllers types on game experience is limited." (Sajjadi, Broeckhoven, & Troyer, Dynamically Adaptive Educational Games: A New Perspective, 2014)

Moreover, it is not clear whether some interaction modalities may be more suitable for some player types than for others. Furthermore, although the theory of multiple intelligences has been around for a long time, there is little research in relation to user interaction, specifically in the context of serious games.

The experiments performed with the Maze Commander game didn't show clear relationships between MI dimensions, preferences for an interaction modality, and game experience. We think that this is mainly due to the fact that the communication aspect of the Maze Commander game turned out to be too dominant. For instance, the fact that the two players were not able to communicate well would affect the game experience more than the use of a different interaction modality. Therefore, in this iteration a new experiment was setup in which the communication aspect was removed, to investigate whether relationships could be found between MI dimensions, game experience, and interaction modality.

1.4 Research Question

Player-centered game design and/or personalization of games based on certain attributes of the players can potentially result in a better gameplay experience, performance and/or learning outcome. In this thesis, we focus on one personality factor, i.e., the intelligences of a person according to the theory of Multiple Intelligences. Furthermore, we narrow down our focus on players who exhibit a high bodily-kinesthetic intelligence. In particular, we want to investigate whether a kinesthetic-oriented interaction modality would have an influence on the game experience for players with a high bodily-kinesthetic intelligence. This results in the following research question:

Can player-centered game design, for the case of bodily-kinesthetic players, lead to a better game experience?

To answer this research question, a game was designed specifically for individuals with a high bodily-kinesthetic intelligence. The players' game experience was evaluated for bodily-kinesthetic players as well as non-bodily-kinesthetic players. The game is called Maze Balancer.

1.5 Experiment

A single-player game was developed to answer the research question. To collect data about the overall gameplay, game experience and gameplay behavior, a system to log quantitative measures of the player's gameplay behavior was implemented, and a questionnaire was used to determine gameplay experience factors. This new single-player game is controlled using a gesture-based controller.

Gesture-based interaction

In recent years several novel controllers have been released for commercial use, one of the most popular being the Kinect, which brought gesture-based interaction into the mainstream. The introduction of several other controllers quickly followed. In this experiment a controller called the Leap Motion is used. In the Maze Commander game the Sifteo Cubes were used for controlling the game's progress. A problem with finding relations between the Sifteo cubes and the multiple intelligence profiles of the players was the fact that the cubes didn't focus on a single intelligence: they have a kinesthetic component, but they also contain a display. The Leap Motion is assumed to be a kinesthetic modality, and therefore a better choice for investigating the relationship between game experience and interaction modality for bodily-kinesthetic players.

Leap motion

(www.leapmotion.com)

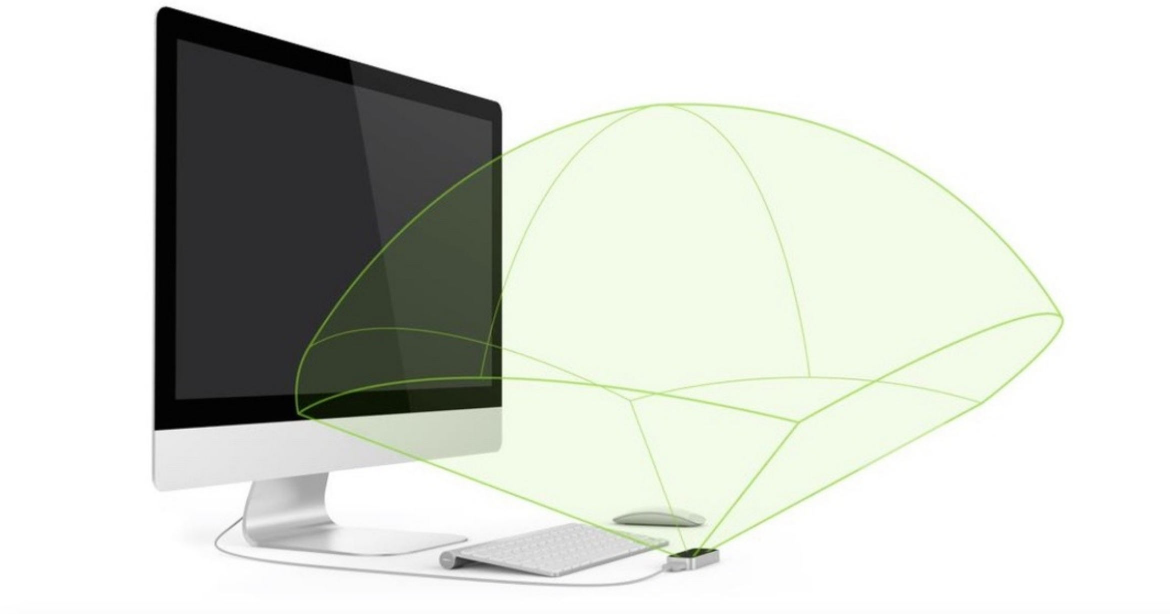


Figure 2 Leap motion: field of view

The leap motion controller is a small USB-device that uses infrared imaging to determine the position of predefined objects in a limited space in real-time (see figure 2). The background service that supports the device then identifies the positions of hands and fingers in the space above the leap motion. Several API's are provided, which support a wide variety of programming languages, ranging from C++ and C# to Python and JavaScript.

1.6 Relevance

Relations between bodily-kinesthetic participants and their experience with the aforementioned bodily-kinesthetic modality are analyzed. Results could provide developers of serious games insight on whether or not gesture-based interaction is a good choice for certain game designs. Significant differences in game experience outcomes between different MI profiles can give an indication whether the MI theory can provide a useful player typology, and would support the use of player-centered game design methods for serious games. Since many adaptive educational systems share similar requirements for the design of adaptive content, the outcomes of this research could aid the development of those systems as well.

1.7 Thesis Structure

Chapter 2 contains the background information on serious games, the theory of Multiple Intelligences, and game experience evaluation.

Chapter 3 contains the literature review investigating adaptive educational systems, player-centered game design, adaptive games, and kinesthetic games.

Chapter 4 describes the Maze Balancer game developed for the experiment. This chapter includes the software design, system architecture, as well as a more in-depth look at some of the implementation aspects.

Chapter 5 contains the results of the experiment, the hypothesis test, and the discussion.

Chapter 6 summarizes the findings of this thesis and concludes with suggestions for future work.

2

Background

- Learning and Games
- The Theory of Multiple Intelligences
- Game Experience Evaluation
- Summary

In this chapter background information regarding the learning potential of games, the MI theory, and game experience evaluation are presented.

2.1 Learning and Games

Many scholars in different research fields support the claim that games carry an inherent educational quality. Starr argues that video games always have an educational role, whether what is taught is considered acceptable or not (Starr/Merkel/Kurki, 2015). Games motivate children by making them part of the domain they are studying, through practicing and problem solving. Most arguments against serious games are about the effectiveness of serious games. It is argued that the lack of design towards game experience often hinders the learning aspect by impairing the immersive quality of these games (Gee, Learning and Games., 2008).

In classrooms it is sometimes difficult to motivate children to learn certain topics, because they do not see a direct reason to solve the problems that relate to the content that is taught. For example a high-school child might ask himself why he or she should learn a specific topic, and become unmotivated. A game can give clear motivation to solve these problems. Games do not only present the game content, but they also stimulate the players to become familiar with the game content. In this way players might find the motivation to learn a specific topic that might have been difficult to learn in a classroom setting.

James Paul Gee argues that games create their own 'affinity spaces', these are spaces (either physical or online) where players of games come together and research aspects of the games played (Gee, Semiotic Social Spaces and Affinity Spaces, 2005). The need for the research done by players in these affinity spaces is a result of trying to solve difficult problems in the game world. There are clear examples of affinity spaces that exist on the Web. In some cases complex educational topics are discussed in these spaces (see figure 3).

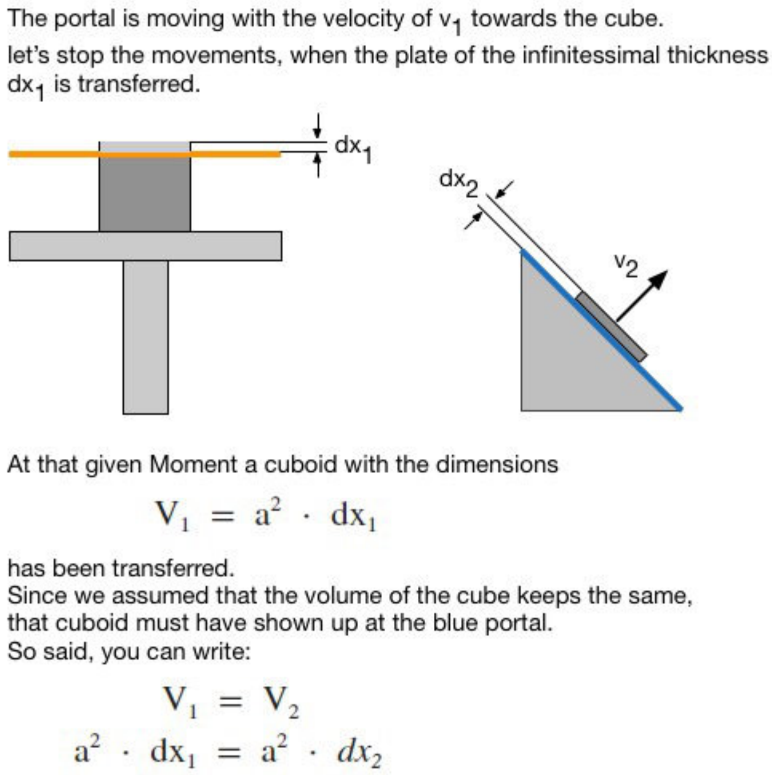


Figure 3 An example of an affinity space where players of the commercial game "Portal" are discussing the conservation of momentum relating to game mechanics. (Scientius, 2016)

Some serious games are quite simple, and might have less potential to support these affinity spaces, but when improvements are made to the game design, affinity spaces might be created for the educational material that was attempted to be taught in the first place. So designing a serious game involves a delicate balance between fun and learning, motivating the player, promoting learning, and in the case of large-scale games the support for affinity spaces.

Effectiveness

Most arguments against serious games are about the effectiveness of serious games. Different researchers are investigating how to measure the effectiveness of a serious game (especially if we look at long-term learning effects). Other researchers are investigating the factors that influence the effectiveness of a serious game. Many studies indicate that a good game experience leads to better learning outcomes.

2.2 The Theory of Multiple Intelligences

The theory of Multiple Intelligences (MI) conceived by Howard Gardner (Gardner, Frames of mind: The theory of multiple intelligences., 1983), states that the intelligence of a human being can be described in several unique intelligence dimensions. In contrast to the general intelligence term, studied in the early twenties by psychologist Alfred Binet (Binet & Simon, 1916), Gardner defines intelligences as "heritable potentials and skills that can be developed in diverse ways through relevant experiences". Several criteria were established for the identification of a unique intelligence.

Criteria for the identification of an intelligence

- It should be seen in relative isolation in prodigies, autistic savants, stroke victims or other exceptional populations. In other words, certain individuals should demonstrate particularly high or low levels of a particular capacity in contrast to other capacities.
- It should have a distinct neural representation—that is, its neural structure and functioning should be distinguishable from that of other major human faculties.
- It should have a distinct developmental trajectory. That is, different intelligences should develop at different rates and along paths which are distinctive.
- It should have some basis in evolutionary biology. In other words, an intelligence ought to have a previous instantiation in primate or other species and putative survival value.
- It should be susceptible to capture in symbol systems, of the sort used in formal or informal education.

- It should be supported by evidence from psychometric tests of intelligence.
- It should be distinguishable from other intelligences through experimental psychological tasks.
- It should demonstrate a core, information-processing system. That is, there should be identifiable mental processes that handle information related to each intelligence.

(Kornhaber, Fierros, & Veenema, 2004)

Over the years many candidate theories were proposed, but a set of 8 intelligences were accepted as sufficiently unique according to the criteria.

Intelligence dimensions

Intelligence	Description
Linguistic	An ability to analyze information and create products involving oral and written language such as speeches, books, and memos.
Logical/Mathematical	An ability to develop equations and proofs, make calculations, and solve abstract problems.
Spatial	An ability to recognize and manipulate large-scale and fine-grained spatial images.
Musical	An ability to produce, remember, and make meaning of different patterns of sound.
Naturalist	An ability to identify and distinguish among different types of plants, animals, and weather formations that are found in the natural world.
Bodily/Kinesthetic	An ability to use one's own body to create products or solve problems.
Interpersonal	An ability to recognize and understand other people's moods, desires, motivations, and intentions.
Intrapersonal	An ability to recognize and understand his or her own moods, desires, motivations, and intentions.

Table 1 The 8 dimensions of intelligence

(Davis, Christodoulou, Seider, & Gardner, 2011)

There are two common misconceptions about the intelligence dimensions. Intelligences are often confused with learning styles (or cognitive styles). Different from a learning style, the operation of an intelligence deals with a specific type of content, like: numerical patterns, phonemes or musical sounds. The other common misconception is the confusion between a domain name and the name of an intelligence. A musician that masters a musical instrument might, for example, carry a higher bodily-kinesthetic intelligence than musical intelligence.

Educational reform

Even though the MI theory has received criticism from the scientific community, in the educational community the MI theory is embraced and applied in many different fields. Even though the theory does not directly call for educational reform, Gardner has himself suggested that there should be a great deal of reform when it comes to addressing these multiple intelligences (Gardner, Multiple Intelligences After Twenty Years, 2003).

"But once we realize that people have very different kinds of minds, different kinds of strengths -- some people are good in thinking spatially, some in thinking language, others are very logical, other people need to be hands-on and explore actively and try things out -- then education, which treats everybody the same way, is actually the most unfair education." (Gardner, Big Thinkers: Howard Gardner on Multiple Intelligences, 2009)

Since the popularity of the MI theory has grown significantly over the last years the, seeing Google search increases of over 2000% over the period 2003-2005 (Waterhouse, 2006), many scholars join in the debate on whether or not the theory is backed by empirical evidence.

Relevance to player centered game design

In a social environment where there is an overwhelming tendency to develop the logical-mathematical and linguistic intelligence, software gives us the opportunity to adapt to the learners, and stimulate the intelligences which are not adequately addressed. Games can provide players with these different ways of interacting with game material, and in the case of serious games, this material could be educational material.

An important stage of player centered game design is to take into account the differences between players. MI theory could provide a good way to differentiate between players.

Profiling practices

There have been a few studies regarding the profiling of a person's MI profile, including long term evaluation studies based on self-assessment (Morris & Leblanc, 1996), evaluation through learning activities (Almeida, Prieto, Ferreira, Bermejo, Ferrando, & Ferrandiz, 2010), analysis based on user behavior (Kelly & Tangney, Adapting to intelligence profile in an adaptive educational system, 2006), as well as the development of the application of the Multiple Intelligence Profiling Questionnaire (MIPQ) (Tirri & Nokelainen, 2011). Since the MIPQ is an instrument that can be applied in a short amount of time, is backed up by empirical studies (Tirri & Nokelainen, 2008), and is widely accepted/used, it is the instrument of choice for this study.

2.3 Game Experience Evaluation

The evaluation of digital games, up until recently, has been a largely informal process. Significant factors for measuring gameplay experience are difficulty to identify. Some attempts have been made at incorporating traditional user experience measures into the game design process (e.g., effectiveness, task completion, efficiency, and error rate) and they can be relevant to a certain degree, but traditional user experience metrics do not suffice in describing the overall game experience (Nacke, Drachen, & Göbel, 2010). Measuring gameplay experience is especially important in the case of serious games, since a good game experience directly relates to a better learning potential (Gee, Learning and Games., 2008).

It is difficult to adequately measure game experience, since there is no single metric that can define game experience. There are in fact many gameplay experience factors that have to be identified and measured.

"The lack of a common vocabulary or experiential taxonomy is not just a struggle for gamers or game reviewers, but equally affects game design professionals and usability engineers." (IJsselsteijn W. , de Kort, Poels, Jurgelionis, & Belotti, 2007)

Current methods

In recent developments IJsselsteijn et al. (2008) have released a game experience questionnaire that is widely reviewed and applied. This questionnaire measures seven different game experience factors:

- Competence (e.g. 'I felt skillful')
- Immersion (e.g. 'I felt imaginative')
- Flow (e.g. 'I was fully occupied with the game')
- Tension/annoyance (e.g. 'I felt annoyed')
- Challenge (e.g. 'I thought it was hard')
- Negative affect (e.g. 'It gave me a bad mood')
- Positive affect (e.g. 'I felt content')

The game experience questionnaire is validated (IJsselsteijn, et al., 2008), and has been widely accepted as the current standard for game experience evaluation, and is used in experiments.

There are two specific GE factors that are easily confused, namely the Immersion and Flow factors. The immersion factor measured by the gameplay experience questionnaire in fact measures imaginative immersion. The state of flow (which is measured in the GEQ) is characterized by the following elements:

- A challenging, often rule bound activity that requires skills
- A task that has clear goals and offers immediate feedback
- An ability to concentrate on the task at hand
- A perceived sense of control over actions, and a lack of sense of worry about losing control
- The merging of action and awareness, i.e., a state of deep and effortless involvement
- A loss of self-consciousness or preoccupation with self
- The transformation of time

(Csikszentmihalyi, 1990, pp. 48-67)

2.4 Summary

In this chapter we have looked at MI theory, game experience evaluation, and profiling practices were briefly mentioned. Since the MIPQ is backed up by empirical evidence it will be used in the experiment. For the game experience evaluation there is the widely accepted GEQ, which will be used in the experiment.

3

Literature review

- Adaptive Educational Systems
- Player-Centered Game Design
- Adaptive Games
- Kinesthetic Serious Games
- Summary

This thesis touches upon different academic fields, i.e. the theory of multiple intelligences, adaptive educational systems, and serious games (see figure 4), which will be discussed in this chapter, as well as the intersections of these fields. Some educational topics often go unnoticed in the studies for serious games, for example, there is little research available linking multiple intelligences to game design. This is why closely related fields will be examined.

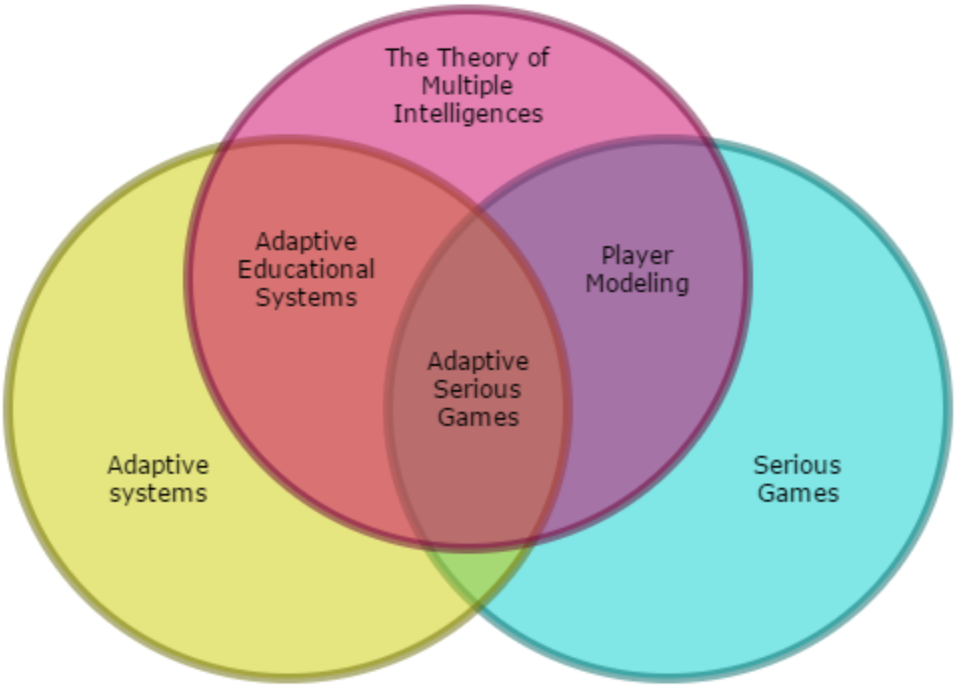


Figure 4 Research context

3.1 Adaptive Educational Systems

One of these related fields is the research on adaptive educational systems. Research on adaptive educational systems has covered many aspects of learning differences, specifically in relation to the MI theory. Adaptive educational systems, as suggested by the term, adapt content and/or content presentation to the users. For the development of serious games, and more specifically games that implement novel modalities, it is important to see how the knowledge that is gained from these adaptive educational systems can be applied to games.

Adaptive educational systems come in the form of intelligent tutoring systems (ITS), adaptive learning environments (ALE), and pedagogical recommender systems (PRS). The adaptation that occurs in these systems is inherently linked to learning differences. One example of an adaptive system that applies the MI theory to differentiate between these learning differences is EDUCE.

EDUCE

(Kelly & Tangney, Adapting to intelligence profile in an adaptive educational system, 2006; Kelly & Tangney, Predicting Learning Characteristics in a Multiple Intelligence Based Tutoring System, 2004; Kelly & Tangney, Evaluating Presentation Strategy and Choice in an Adaptive Multiple Intelligence Based Tutoring System, 2004)

EDUCE is a (well documented) ITS, that addresses the challenge of adapting information presentation to the MI-profile of an individual learner. EDUCE attempts to present the learner with a personalized representation of a pedagogical model, by using information from the domain and the student as input for a predictive engine.

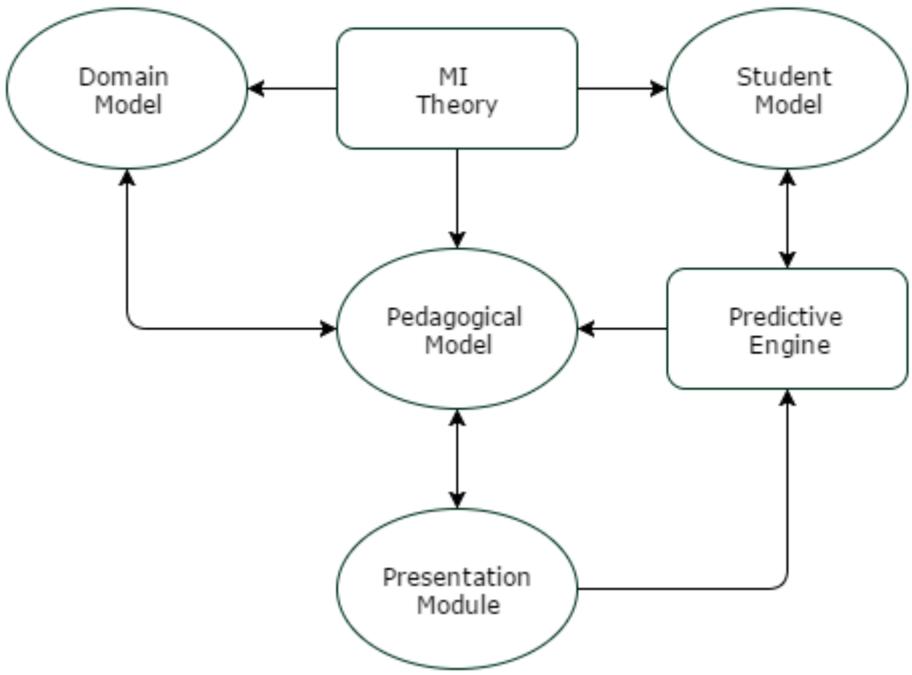


Figure 5 EDUCE architecture, taken from (Kelly & Tangney, Evaluating Presentation Strategy and Choice in an Adaptive Multiple Intelligence Based Tutoring System, 2004)

The student model is largely based on the MI theory. Another part of the student model is built by monitoring the user's behavior. The system measures the following:

- Did the student spend minimum amount of time using the resources?
- Did the student spend a long time using the resource?
- Did the student use only one resource or multiple resources?
- Did the student use the resource more than once?

- Did the student attempt a question after viewing the resource?
- Did the student attempt a question after viewing?

The domain model is constructed by knowledge gathered from experts and educators. Different content from the domain will be presented to the learner in different ways. Variables of the student model are used as input for an A.I. algorithm (Naïve Bayes), allowing the system to adapt to the student model by predicting his or her preferred presentation mode.

Development of an Adaptive Learning System applying Howard Gardner's Multiple Intelligences

(Lee & Oh, 2013)

The system that is discussed in this study is a web-based application. The MI profiles of the users are evaluated by asking a set of forty-nine questions. Once the MI profiles are established, the three outstanding intelligence types (the ones with the highest scores) are used in order to provide personalized learning material. Separate implementations are realized to provide learning materials, and every implementation is related to one of the intelligence dimensions.

Adaptation practices

The adaptation in adaptive educational systems happens by adapting the curriculum sequence (Brusilovsky, 1998), or by adapting the presentation mode. Establishing user profiles allows for this adaptation. In the reviewed studies on adaptive systems, two common profiling practices have come up, one being the use of questionnaires, the other being user behavior measurements. As seen in the EDUCE system, logs of user behavior provide input for classification algorithms in order to determine the adequate content presentation. Since the Naïve Bayes algorithm that is applied in the EDUCE application has to be trained, data linking user profiles to interaction modes could lead to improvements on the effectiveness of such classifications, and allow for more adequate adaptations.

Relation to serious games

Serious games share many similarities with adaptive educational systems. Even most of the motivations for adopting an intelligence tutoring system are similar to those of serious games.

- Poses problems
- Provides support to solve these problems
- Redirects mistakes
- Provides encouragement

In the EDUCE system pedagogical models were built on predictions that were based on data from the student model and the domain model. If we consider the game content of a serious game to be educational content, then the following elements could be considered the serious games counterparts to the elements of the adaptive educational systems.

Adaptive educational systems	Serious games
Student model	Player model
Presentation mode	Game world / Interaction modes
Domain model	Domain model
Educational content	Game content
Curriculum sequence	Game content sequence (narrative)

Table 2 Relations between adaptive educational systems and serious games

The curriculum sequence is a sequence of educational content, and since the content of a serious game is by definition educational, the sequence in which game content is presented could be considered the equivalent of a curriculum sequence. In many games the sequence of game content is determined by the storyline or another form of narrative. When games do not have a storyline, they often offer several levels or stages, in which different parts of the game content are introduced. Adaptive educational systems are inherently based on a user-centered design since they adapt to the users. The experience and learning outcomes of the users are important measures to whether or not adaptation was successful. For the development of effective serious games similar observations have to be made in order to determine the effectiveness of a serious game.

3.2 Player-Centered Game Design

In this section several attempts at defining a player-centered game design process will be discussed. Since player-centered game design is a fairly new direction of research, there is still a wide-range of very different approaches.

From Usability to Playability: Introduction to Player-Centered Video Game Development Process

(Sánchez, Zea, & Gutiérrez, 2009)

This reviewed study describes a way to characterize the player experience, and proposes a player-centered game design methodology. The goal of their research is to move from usability to playability. The study presents seven playability factors, as a result of *"Analyzing several video games and their different characteristics"*.

- Satisfaction
- Learnability
- Effectiveness
- Immersion
- Motivation
- Emotion
- Socialization

The study was reviewed, because it shows a common pattern in player-centered design research. Many studies propose their own set of player experience descriptions, and provide no empirical evidence to back up any of the factors. The proposed immersion experience factor consists of five elements: conscious awareness, absorption, realism, dexterity, socio-cultural proximity, and contains elements of what many others described as flow (IJsselsteijn W. , de Kort, Poels, Jurgelionis, & Belotti, 2007) (Csikszentmihalyi, 1990).

Most of the player-centered design studies that propose these kinds of novel game experience evaluation methods fail to describe the criteria for the game experience factors as well. In the conclusion of the reviewed study they mention that they are working on a conceptual model of a video game which will enable them to specify the playability characteristics.

Game experience

Evaluating games based on a certain sets of experience factors is an essential part of player-centered game design. Even though IJsselsteijn, et al. mentioned that a standard for game experience assessment (IJsselsteijn W. , de Kort, Poels, Jurgelionis, & Belotti, 2007), like the well-known ISO usability standards (ISO 13407 and ISO 9241-11) is not likely to emerge any time soon, the GEQ has been validated, and is widely used. A common description for game experience will allow for the comparison of different games, as well as their relations to different player typologies.

Player-Centered Game Design: Player Modeling and Adaptive Digital Games

(Charles, et al., 2005)

The main motivation for the player-centered game design approach proposed by Charles, et al. is that it could produce games that have a better game experience regardless of gender age or experience. For this approach player models are the core indicators for the adaptation process. They mention that differentiating between players is not a straightforward issue, because it is hard to identify player characteristics that are relevant for different contexts.

"A player typology that attempts to anticipate different styles of play simply cannot take into account all the factors that might potentially influence the gameplay experience. Conversely, from a technical point of view, it seems obvious that a level of emergence that would be able to adapt to every possible play-style is impossible to implement within the limits of current technology."

They mention that a player typology has two different challenges:

- It has to be specific enough to allow for widely different play styles
- It must be general enough to be applied across different genres, platforms and cultures

MI theory is never mentioned in the study, but might provide the answer to the aforementioned player typology issue, since it addresses both of the presented two challenges. It is specific enough to allow different play styles, and is not affected by the game context.

Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences

(Barzilai & Blau, 2014)

A study conducted on the educational game Shakshouka Restaurant game, a game in which players learn about costs, prices and profits by running a restaurant, revealed that a previously tested measure of flow (Brockmyer, Fox, Curtiss, Mcbroom, Burkhart, & Pidruzny, 2009; Csikszentmihalyi, 1990), as well as a measure of enjoyment, correlated to the perceived learning measurement. They describe flow as a delicate balancing of challenge and skills, enjoyable challenges are at a level of difficulty that avoids being too easy hence boring or too hard and hence frustrating (Tension).

Figure 6 Shakshouka Restaurant, taken from (Barzilai & Blau, 2014)

By performing a qualitative analysis they found that many of the game elements which the players enjoyed the most also caused the highest perceived learning outcomes.

Learning in relation to game experience

As studies have shown, there is a strong correlation between certain game experience factors and learning. Game experience factors such as flow, challenge, andpositive affect all contribute to learning (Ainley, 2006; Cordova & Lepper, 1996). If we take this into account, any game promotes learning as long as it has a good game experience. In the case of serious games it is however important that the game content represents the domain's educational content.

Gameplay behavior in relation to game experience

In a first time study on the relation of game behavior to game experience an attempt was made at linking real-time data about the players' behaviors to game experience measures (van den Hoogen, IJsselsteijn, & de Kort, 2008). The (FPS) game they used for the experiment is Half Life 2. They performed real-time measurement of the player's mouse force, chair movement (pressure sensors), and body movement (accelerometer). They found that maximum mouse force was correlated to frustration and challenge, and inversely related to competence. And they found that mean accelerometer movement was correlated to challenge.

A problem with the current game experience questionnaire is that it requires the player to interrupt the gameplay experience and fill it in. Correlations between game behavior and gameplay experience, allow for the implementation of real-time player experience measurements. For example: the correlation revealed in the above study between maximum mouse force and challenge, allows for the implementation of a basic real-time measurement of challenge.

An advantage of real-time evaluation is that the game experience measures based on game logging are potentially more robust than questionnaires since the values are not consciously controlled.

The implementation of real-time player experience measurements will also allow for the creation of real-time adaptive games.

3.3 Adaptive Games

Adaptive games inherently include a player-centered design by dynamically adjusting the game content sequence to a player model. Similar to the adaptive educational systems, different game world and interaction modes are presented based on the player model and domain model. Analyzing previous adaptive games studies could provide insight on player modeling techniques. To date there are but a few examples of truly adaptive games, nevertheless some findings will be discussed.

Intelligent Adaptation of Digital Game-Based Learning

(Magerko, Heeter, Fitzgerald, & Medler, 2008)

The main motivation for the development of adaptive games as mentioned in the paper is that higher motivation among students will improve learning. The goal of the proposed adaptive games is to motivate different students with different learning styles, by adapting the game to the player.

The problem of availability of choice is addressed. In learning situations, students often only have a single educational game available for a wide range of different players, whereas commercial games that would not connect to a player would simply be dismissed.

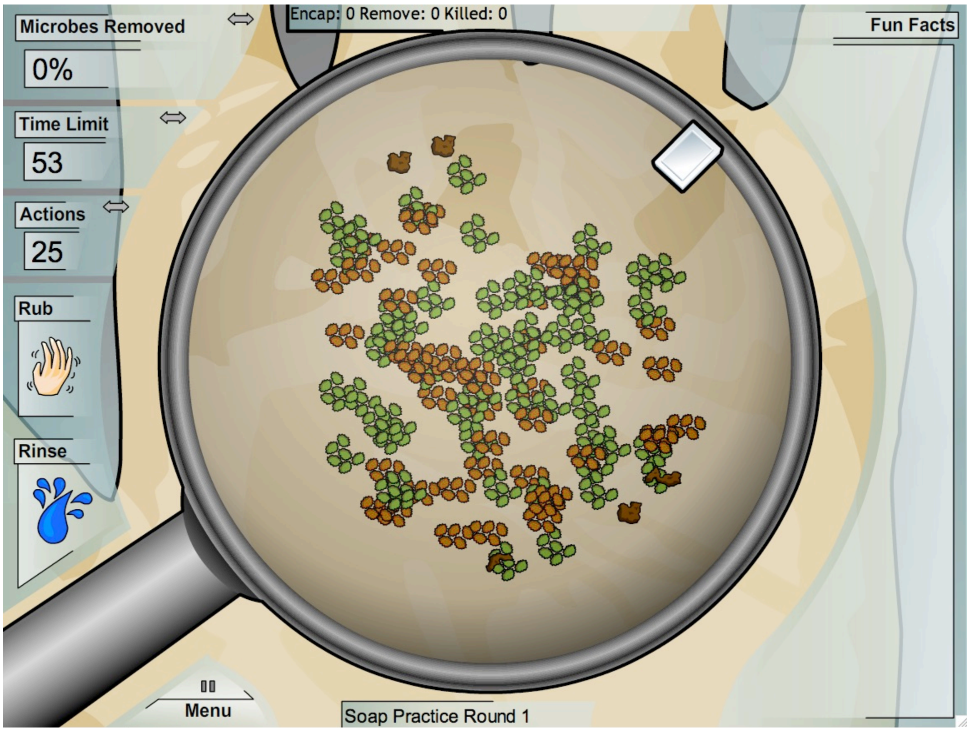


Figure 7 S.C.R.U.B., taken from (Magerko, Heeter, Fitzgerald, & Medler, 2008)

In the adaptive game S.C.R.U.B. (Super Covert Removal of Unwanted Bacteria) the student is taught about several biological topics. The game design involves an iterative process, going through: analysis, identification and mapping. A questionnaire is used to identify some of the player's characteristics, based on this and other analysis, an instantiation of an abstract game is presented.

Adaptive Experience Engine for Serious Games

(Bellotti, Berta, Gloria, & Primavera, 2009)

The study presented in this paper proposes a so-called experience engine. The main purpose of this engine is to sequence game tasks based on user profile (player model) data and task descriptions. These task descriptions include expectations for learning outcome and game experience. These tasks are then stored in a repository by game designers (game content/domain model). A game author then composes a game by selecting a collection of tasks, and by establishing delivery strategy requirements (see figure 8).

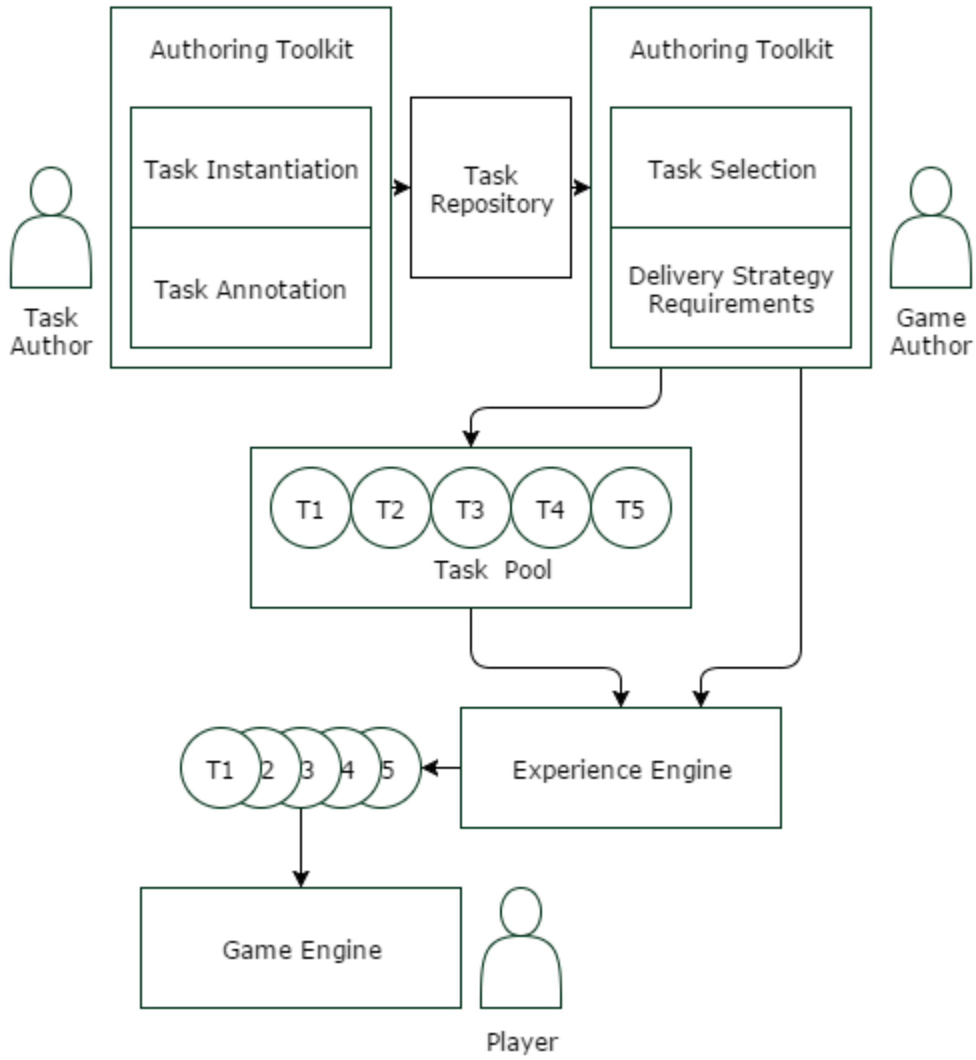


Figure 8 Workflow and high-level architecture of the experience engine system

The task repository stores semantic annotations to describe the tasks. Based on the task pool and delivery strategy, the experience engine outputs a game.

Game							
Objective 1				Objective 2			
Mission 1		Mission 2		Mission 3		Mission 4	
Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8

The game content sequence is presented by performing a depth-first traversal of the task tree output by the experience engine. Starting from the root, the game introduces the first objective, mission, and task.

The designers of the system studied intelligent tutoring systems (ITS), but argue that the adoption of ITS concepts is difficult to realize in games since games need to provide meaningful narratives. Even though the authors of the paper considered the adoption of ITS concepts to be difficult, the proposed system bares many resemblances to an ITS. Some of the main differences are in the player modeling and the fact that there is no separation between the game content (task repository) and domain model. Both the task author and game author role seem to be related to game design, whereas ITS developers bring in domain experts to build the domain model. The player model was also built in a similar way as the user model is built in ITS. Dismiss propensity, learning propensity, fun propensity, trial and error propensity, and learning outcomes were all used to describe the player model. A big difference between, for example, EDUCE and this system is that the EDUCE system adopted the MI theory to model the user.

Adaptation practices

The adaptation practices currently applied in adaptive games seem to be based entirely on arbitrarily assigned measures, which were the results of trial and error. Player attributes were assigned by combining game behavior measures, but none of the studies showed a formalized method for measuring game experience, or learning characteristics.

"An important future direction of the research will concern user studies. They will involve both authors and end-users. In particular, it will be necessary to qualitatively and quantitatively assess how the system is able to improve knowledge/skill acquisition in the context of challenging and compelling game adventures. Test results will give key indications on how to improve the model and inform the design of new supporting algorithms." (Bellotti, Berta, Gloria, & Primavera, 2009)

3.4 Kinesthetic Serious Games

The experiment performed in this master thesis investigates whether a player-centered game design is applicable for kinesthetic players. Some studies showing the effectiveness of targeting kinesthetic players in educational contexts will be addressed.

Learning Geoscience Concepts Through Play & Kinesthetic Tracking

(Vattel & Riconscente, 2016)

The Geomoto project is a series of games developed by a game development company called GameDesk. Large-scale studies were performed on simulated games to study the effects of kinesthetic learning in a classical classroom setting.

The goal of the project is to engage students in kinesthetic learning trough movements and actions, replacing what they refer to as more passive forms of learning, such as reading and lecture based instruction. The participants of their experiments included 6th to 9th grade students. The focus of the learning goals of their games was within the domain of geoscience. The games offer a dynamical model for geological phenomenon.

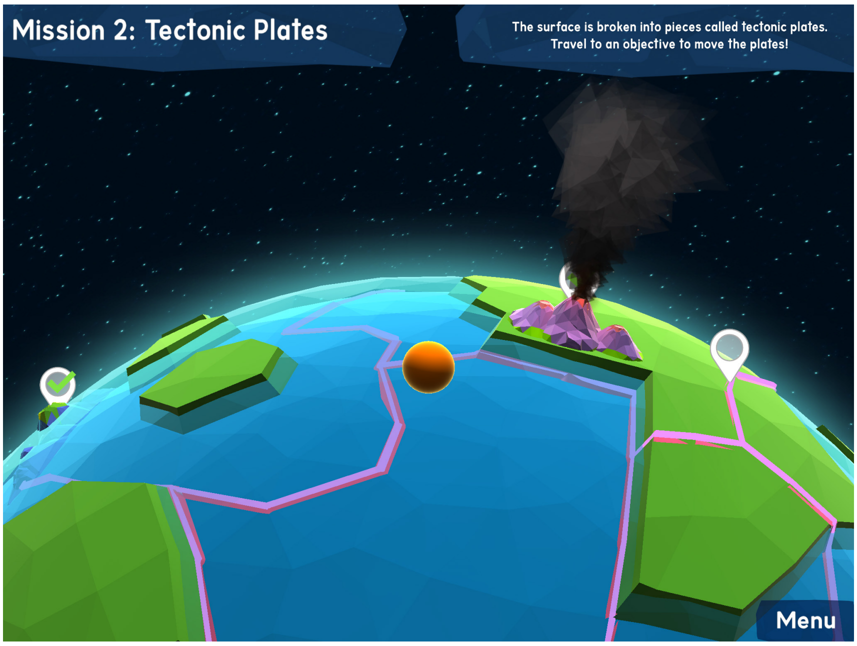


Figure 9 Geomoto

The game design process they employed what they called an "Evidence Centered Design", in which some enacted player mechanics would provide evidence of learning. Working with content experts they revisited prototypes for teacher and student testing. Two of the games they developed were using the Leap Motion Controller. Pangean, a game which covers the topic of continental drift across the earth's surface, and Geomoto (see figure 9) in which plate tectonics, earthquakes, and land formation was covered. Some of the modalities they explored were the Wii, Kinect, and Leap Motion. They found that the Leap Motion controller was the ideal technology for the traditional classroom setting, because of its small size, as well as the fact that it has a limited amount of interference from surrounding students. From discussion with the Leap Motion manufacturers they learned that the devices could be embedded into laptops and desktops easily, possibly making them a ubiquitous technology in classrooms.

The "Evidence Centered Design", which is addressed in this study, contains elements of player-centered design in the way that it makes concepts easier to grasp through a more applicable modality. They argue that certain topics on geoscience are often hard to grasp for young students. They collected empirical evidence for game evaluation, and what they found is that learning by physically interacting with the material was very effective. Their conclusions revealed the following:

"The evaluations for all three of the geoscience modules showed significant knowledge gains from pre to post. The student improvements from pre to post on these tests ranged from an average of 5% all the way up to an average of 25%. Results for the field accretion game showed improvements of 25%. When students played the Geomoto game, they showed improvements of over 11% from pre to post. For the Pangean game, we saw improvements up to 25%. Results from this evaluation study suggest that the geoscience games are both engaging and educational."

The difference between the research presented in this paper, and the analyzed player-centered design is that the Geomoto project did not take into account any learning differences. The results they show are for the entire population, but might have been significantly different for different types of learners. For example, the increases indicated above might have been an increase for kinesthetic players, but a decrease for all other players.

Gesture-based games in the classroom

The technologies for gesture-based control are becoming cheaper and smaller. The leap motion has several advantages and disadvantages over the Kinect, when it comes to classical classroom settings. The main advantage is that the leap is lightweight and mobile. The other great advantage is that many leap devices can be devices used in the same space, with little interference between different users. However the limited range of the leap motion remains a problem. A disadvantage over the Kinect is that only one person can use a leap at a time, and multiple devices will have to be bought. As mentioned in the GameDesk research there might soon be the possibility to have a ubiquitous technology for gesture-based control built into laptops.

Teaching Arabic Sign Language through an Interactive Web based Serious Game

(Lotfi, Amine, & Mohammed, 2015)

The game discussed in this article is a Leap Motion controlled game in which the player progresses through the learning of the Arabic sign language. A multilayer perceptron analyses the leap motion input to detect certain hand gestures. A game session has a certain time limit in which the learners perform as many Arabic signs as possible. 10 deaf children played the game. The data collected indicated that all students showed significant improvements on their score over three game sessions.

Assumptions on kinesthetic qualities

In the games that were presented in the aforementioned studies, the games are referenced as kinesthetic games, but on closer examination most of the kinesthetic qualities connected to the games seem to be based on assumptions. For example the leap motion is used in the Geomoto game, but there is no evidence that the leap motion is a modality that supports kinesthetic players. Kinesthetic players might require physical feedback, and even thought the design process is called an evidence centered design there is no mention of this. They did prove that the kinesthetic game had an effect on learning, but they missed an important detail where they did not distinguish between the kinesthetic learners and the learners that did not have a high kinesthetic intelligence. It might be that kinesthetic learners learned very effectively and non-kinesthetic learners did not learn anything at all. Since all the students are treated as one group we have no insight on these details.

3.5 Summary

Differentiation between player types is important since generalizing the entire player population might lead to misleading outcomes. A good game experience can be measured for the complete player population, but this doesn't mean that the game allowed for a good experience for each player type. There is little research concerning player typologies in relation to learning differences. The MI theory could form a good basis to differentiate players. Game experience differences relating to player typologies based on multiple intelligences will be investigated our experiment.

As indicated in the literature, a good game experience promotes learning. A robust and objective way to measure game experience is essential. One of the most robust ways to measure game experience is to measure game experience in real-time, based on game behavior. Another reason to employ real-time game experience measurements is that specific events in the game might have a large impact on the overall game experience. A game might be evaluated positively in terms of game experience, while a single event in the game might have had a very negative effect. Generalization over the entire game content can also lead to misleading results.

4

The Maze Balancer Game

- Requirement Analysis
- Game Concept
- System Architecture
- Software Design
- Implementation Aspects
- Summary

This chapter describes the concept and design of the Maze Balancer game. The requirement analysis is presented, which includes the requirements for the experiment, as well as the resulting game concept and system design. Several implementation aspects will be mentioned to explain the core functionality of the game in greater detail.

4.1 Requirement Analysis

Since the aim is to research new possibilities for player-centered game design by investigating the relationship between MI, a specific modality, game experience, and game behavior, the game that was developed for this experiment had to log data on gameplay behavior. The data could then be analyzed for different player typologies (MI profiles). Because there is no information on the connection between specific MI profiles and preferred modalities, common assumptions about kinesthetic preferences are investigated as well. The requirements for the software were established in a series of discussions with the research supervisors.

Game session

A certain amount of playable content was required for the experiment. The decision was made that a game session had to take from 15 to 25 minutes, 25 minutes being the maximum amount of time for one participant to partake in the experiment.

Kinesthetic qualities

The game must have several kinesthetic qualities to test some of the assumptions. Some examples of assumed kinesthetic game aspects are movement resulting in action, object manipulation, interaction with physics and gravity and timing. It is assumed that when kinesthetic players will be confronted with these types of game elements, they will feel more challenged and more motivated to play the game.

Logging

The software should be able to measure many aspects of the gameplay. Robustness also plays an important role here since the experiment can only be performed once.

Flow

Even though the game design is in some ways limited by the experimental requirements, the game content has to be interesting enough for the players to be enjoyable. If players will be bored, the collected data will not be useful.

Performance pressure

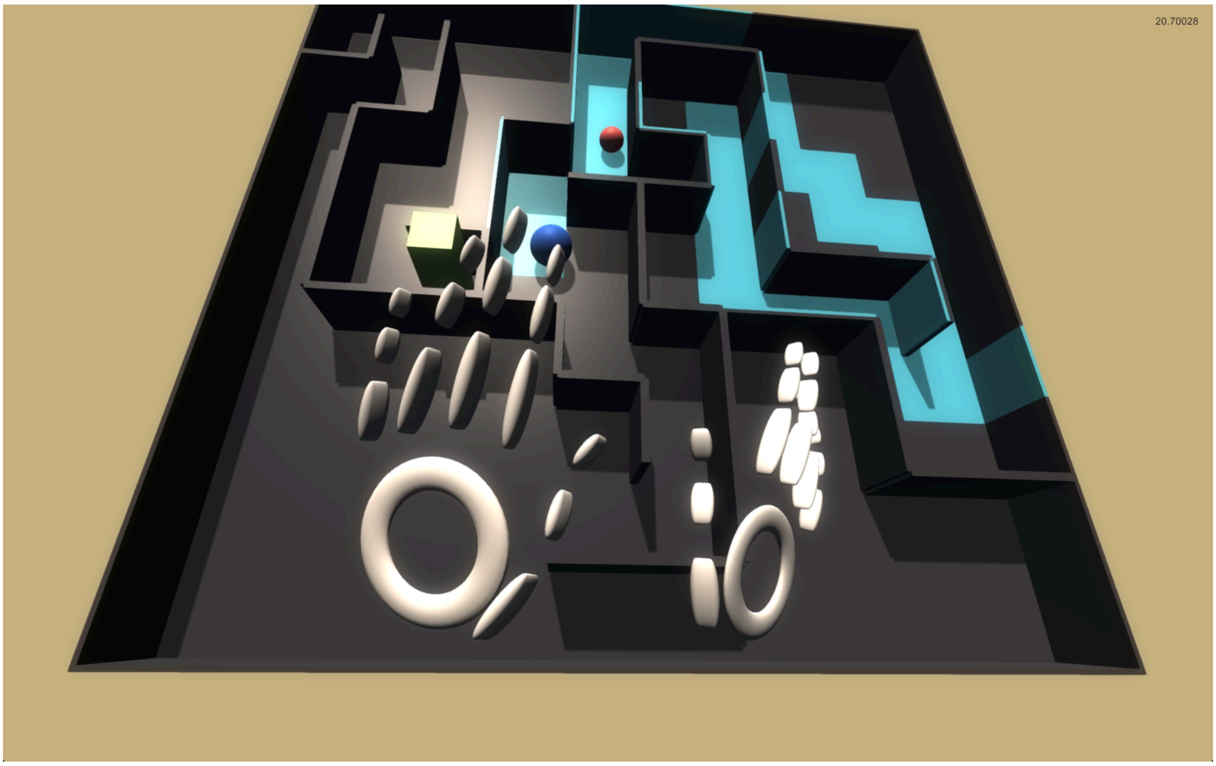
The decision was made to make a game that did not have a losing condition. A losing condition could influence the data based on how individual players would cope with loss.

Consistency

Games need to adhere to a consistent set of rules. Consistency within the game world is important for players, since inconsistencies make it hard for the players to learn the rules of the game. Inconsistencies could influence the outcome of the gameplay behavior measurements.

4.2 Game Concept

Since there is no established method on how to design games for specific intelligence profiles (e.g., kinesthetic players), the game is designed to provide relevant data that can help us develop a player-centered design method. To ensure that relevant data is produced by the game on whether or not the assumed kinesthetic qualities were in fact favorable to kinesthetic players, the game content has to be limited to represent only these qualities. It is hard to get relevant data from games with a lot of different game elements, since all game elements may influence the game experience.



We opted for a physics-based game, controlled by the leap motion controller. The game consists of a maze, a ball, and a target, and in a higher difficulty setting obstacles are introduced. The goal of the game is to bring the ball to the target, by manipulating the three-dimensional tilt of the maze. When the player tilts the maze in the right angles, gravity allows the player to move the ball towards the target. Tilting the maze is done by hand movements in the air, which are captured by the leap motion.

4.3 System Architecture

The system has several components (see figure 10). The leap motion is supported by a background process, the *leap motion service*, which receives the hand data coming from the USB-port. Next to that there is a *leap motion configuration application* that can communicate with this background service and change several configurations concerning the data interpretation. This configuration app also offers the possibility to calibrate the leap motion by playing a small calibration "game".

On the software end the data is interpreted by the *Leap Motion API*. In Unity C# scripts, the Leap Motion API was incorporated into the Unity game engine.

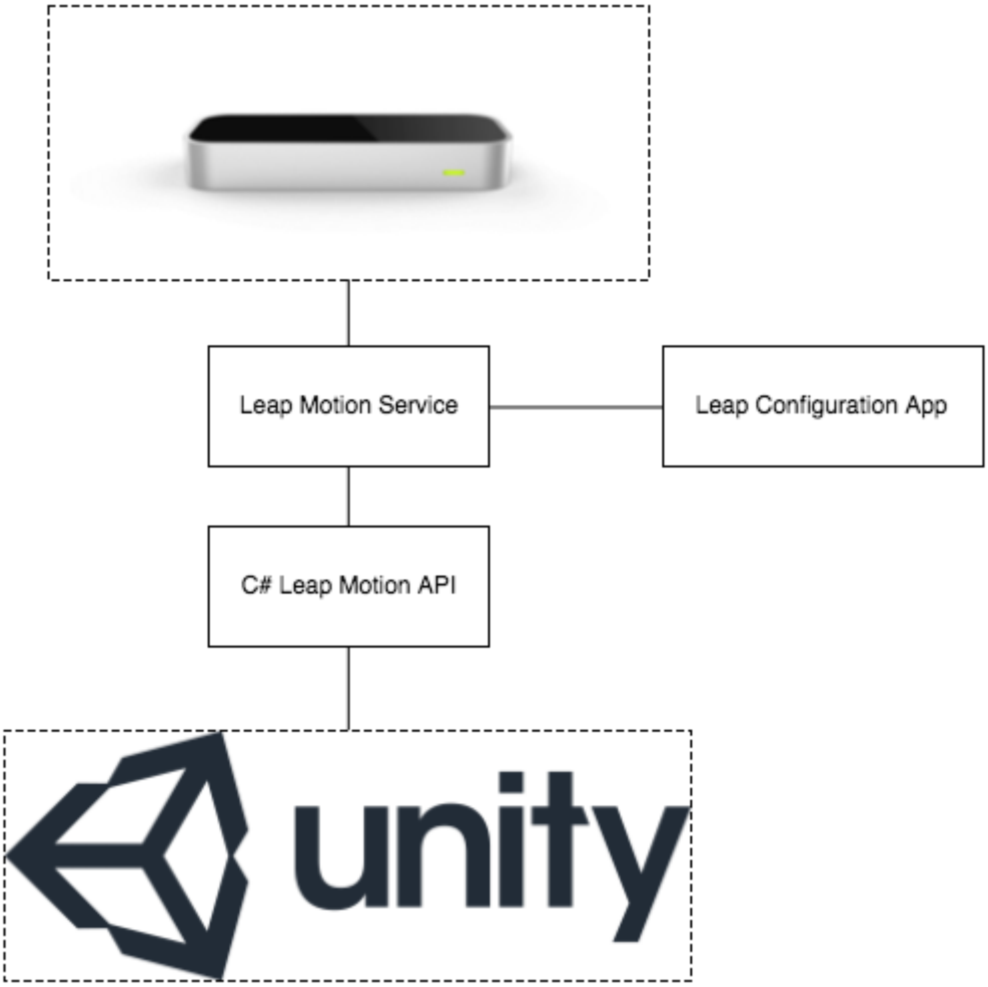


Figure 10 Software architecture

Unity game engine

The unity game engine allows for the cross platform development of 2D as well as 3D games. So-called game objects can be placed in the game world and components can be attached to these game objects. All game objects have a transform component which controls the position/rotation of the object as well as the dimensions. A unity project holds a set of assets which include prefabs of objects. These prefabs are prototypes for game object instantiation, and store the values for required variables.

For an Object-Oriented design within the Unity game engine, C# scripts can be attached to game objects as components. Game objects can be instantiated through these scripts as classes that are attached in C# script components. For example, a game object with a script containing a Ball class can be instantiated as an instance of Ball. Through the game object interface the C# scripts can then manipulate transforms or other component variables.

Leap Motion assets

The Leap Motion SDK offers ways to incorporate hand game objects inside the unity 3D world space. This is done by mapping the so called "leap space" to the unity world space. The precision and range of this leap space are however limited. This ultimately leads to the situation where the eventual unity world space in which the game takes place should also be limited. If the scaling between the two types of spaces is too big, the interpreted hand movements become imprecise and jittery.

4.4 Software Design

Since game objects have to be instantiated as C# objects, the factory pattern provides a useful way to store this logic inside object creation methods. The observer pattern is used to track the maze agent transitions and composition is used to construct the maze. In the following figure a simplified UML class diagram for the Maze Balancer game is presented.

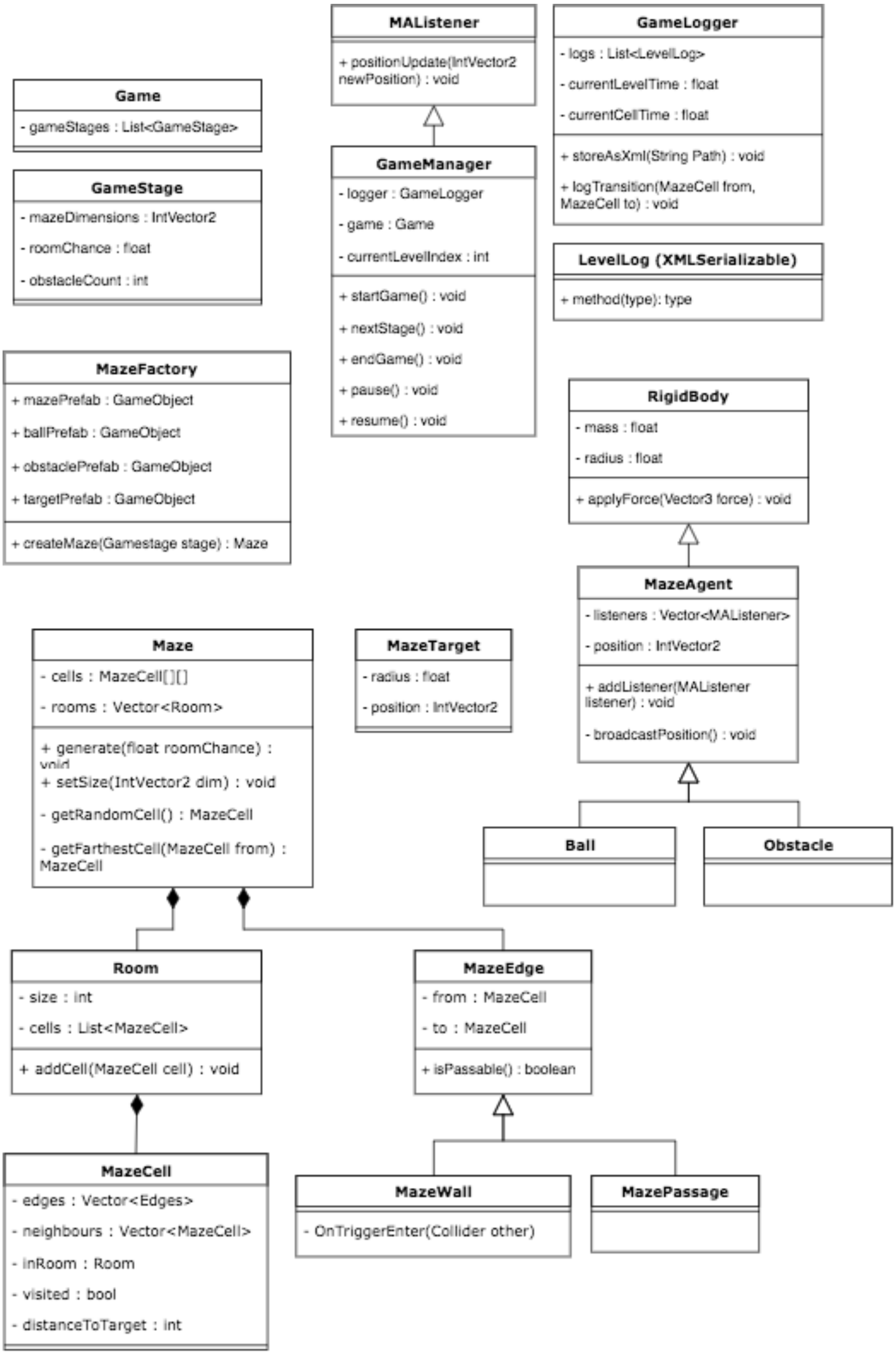


Figure 11 Simplified Maze Balancer design (UML class diagram)

4.5 Implementation Aspects

Maze generation

Procedural generation was used to generate game content. This allowed for an effective way to generate different difficulties, sizes, etc. making it easy to meet the requirements for the experiment. Even though the game content is generated, pseudo randomness is at the core of the algorithm to make sure that all players will receive mazes with similar difficulty settings.

To generate the levels of the game, several aspects of the experiment had to be taken into account. The levels had to be different, but not too different to introduce a difficulty bias for different players. A total game session should result in a significant amount of data, but shouldn't be too long for the player to lose his/her interest. And the levels should never be too short to be able to measure anything significant.

To generate the maze a backtracking algorithm was implemented. The base backtracking generation maze generation algorithm is described by the following pseudo-code:

```
Setup a grid of X by Y grid cells
Add all cells to the active cell list
Start at a random position within the setup grid
While cells in active cell list
      Pick a random uninitialized direction D
            If cell in direction D
                  Create wall
            If no cell in direction D
                  Create passage
                  Create cell
      If no more uninitialized directions
            Remove from active cell list
            Move one step back to the previous active cell
Add start position at random position in grid
Place the target at the farthest position from the start position
(Dijkstra's algorithm)
```

Since this algorithm can only result in corridors that are a single cell wide, the addition of so-called rooms was implemented, resulting in the following pseudo-code:

```
Setup a grid of X by Y grid cells
Add all cells to the active cell list
Start at a random position within the setup grid
While cells in active cell list
      Pick a random uninitialized direction D
            If cell in direction D is in the same room
                  Create passage
            If cell in direction D is in another room
                  Create wall
            If no cell in direction D
                  Create passage
                  If random number < room chance
                        Create cell in new room
                  Else
                        Create cell in same room
      If no more uninitialized directions
            Remove from active cell list
            Move one step back to the previous active cell
Add start position at random position in grid
Place the target at the farthest position from the start position
(Dijkstra's algorithm)
```

With this new room generation algorithm the difficulty of the generated maze is manipulated by setting the room generation chance. A higher room generation chance will result in narrower passages, while a lower room generation passage leads to larger (easier to traverse) rooms.

Level sequencing

The game levels are created by instantiating new mazes. The maze instantiation is depending on a level model input. Prefabs of the level model can be edited to allow for the creation of different difficulty settings.

Game logging

A high-frequency timer co-routine (update mechanism in unity) checks whether or not a ball enters a new grid cell. Whenever a grid cell is entered, the Ball (MazeAgent) broadcasts the transition to its listeners, resulting in the logging of several variables by the GameLogger.

4.6 Summary

The Maze Balancer game was successfully implemented using the Unity 3D engine, the leap motion SDK, and C#. The Maze Balancer allows for precise logging of the gameplay progress, fulfilling the logging requirement. The software is able to generate game content, fulfilling the game session requirement. Some requirements are tested in the experiment. The kinesthetic quality of the game will be tested in the experiment by comparing the game experience for the bodily-kinesthetic participants to game experience results for non-bodily-kinesthetic participants. Other requirements that will be tested in the experiment are flow, robustness, and consistency.

5

Experiment

- Hypothesis
- Methodology

This chapter contains the hypothesis and methodology for the experiment. The experiment consisted of four stages which will be discussed in detail.

5.1 Hypothesis

Based on our research question "Can player-centered game design, for the case of bodily-kinesthetic players, lead to a better game experience?", we formulated the following hypothesis:

People with a high bodily-kinesthetic intelligence will have a better gameplay experience playing the Maze Balancer game.

5.2 Methodology

An experiment was performed with 22 international students. These participants were asked to play the game, while different variables were measured. Afterwards the participants were asked to fill out the Game Experience Questionnaire to measure their game experience and answer some open questions.

Instruments

Two instruments were used during the experiment: the Multiple Intelligence Profiling Questionnaire (Tirri & Nokelainen, 2011), which was used to determine the participants' MI profiles, and the Game Experience Questionnaire (IJsselsteijn, de Kort, & & Poels, Digital games as social presence technology: Development of the social presence in gaming questionnaire., 2007), which was used to collect data on the game experience.

Demographics

The sample consisted of 22 international students, of which 11 were profiled as having a high bodily-kinesthetic intelligence, and 11 were profiled as having a low bodily-kinesthetic intelligence. These participants were identified in the first stage of the experiment (see below). None of the participants had any prior experience with the Leap Motion modality.

The experiment consisted of four stages.

Stage 1: MI-Profiling

114 participants filled in the Multiple Intelligence Profiling Questionnaire (Tirri & Nokelainen, 2011). This questionnaire consists of 30 questions, measuring 8 dimensions of intelligence. Four questions were asked about each intelligence. Answers were given on a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree". A summation of the four values entered by the participants relating to the bodily-kinesthetic intelligence determined which candidates had a kinesthetic intelligence rating of 16 or higher (out of a possible 20). This led to the identification of 11 kinesthetic and 22 non-kinesthetic participants. Out of the 22 non-kinesthetic participants 11 were randomly selected to balance the sample.

Stage 2: Gameplay session

The participants were invited to play the game. One game session consisted of nine levels. The levels were generated in three sets of three, of which every set had its own difficulty setting. While the participants were playing the game, several variables were measured, the most important measures being exploration and speed.

A procedure was established in which the participants were given a set of instructions before starting the game session. In the instruction procedure, players were given the following hints:

- The game world consists of a ball in a maze that can be tilted with two hand gestures.
- The ball has to be directed towards the green target.
- The controlling hand movements were demonstrated.
- The leap motion has a limited range.
- An indication was given of the leap motion range by demonstration.
- Whenever a hand is out of range an icon will appear and the game will be paused (including the logging).
- There are several levels, and the game will end by itself.

The gameplay behavior was measured and processed in several stages. The game logger software performed a low-level logging, in which it recorded every step of the ball from one maze grid position to another. The following variables were logged on every maze grid step transition:

- Start coordinate (x, y)
- End coordinate (x, y)
- Distance to target (in amount of cells)
- The velocity of the ball
- The time spent on the previous cell
- The amount of walls hit on the previous cell
- The amount of obstacles hit on the previous cell
- The room size in which the previous cell is located

From Cell	To Cell	Distance	Velocity	Time Spent	Walls Hit	Obstacles Hit	Room Size
Coord: x:3 y:8	Coord: x:4 y:8	28	1.221504	0.9599996	0	0	30
Coord: x:4 y:8	Coord: x:4 y:7	27	1.334722	0.14	0	0	30
Coord: x:4 y:7	Coord: x:4 y:6	26	1.708006	0.8399997	0	0	30
Coord: x:4 y:6	Coord: x:5 y:6	25	1.7004	0.02	0	0	30
Coord: x:5 y:6	Coord: x:5 y:5	24	0.5331668	0.8599997	1	0	30

Figure 12 A level log

For every level played a log was recorded. An example is shown in figure 11. In the processing stage, these level logs were compiled into higher-level gameplay behavior measures over the entire playing session. The advantage of this approach was that we could experiment with different definitions for the behavior measures, without affecting the original logs.

Stage 3: Game experience questionnaire

In the third stage the participants were asked to fill out several modules of the Game Experience Questionnaire. The modules used from the GEQ were the Core module, the In-game module, and the Post-game module. All questions were answered on a 5-point Likert scale, ranging from "not at all" to "extremely". Several GE factors were calculated by averaging the outcome of the related questions. Since the game did not have a storyline, one question from the Sensory and Imaginative Immersion part of the Core module was dropped. This did not affect the validity of the GE-factors since additional questions are included in the GEQ. As mentioned in the GEQ, a robust measurement requires five items per component.

The resulting questionnaire had the following layout:

Core Module

- Competence: 5 questions
- Sensory and Imaginative Immersion: 5 questions
- Flow: 5 questions
- Tension/Annoyance: 3 questions
- Challenge 5 questions
- Negative affect: 4 questions
- Positive affect: 5 questions

In-Game Module

- Competence: 2 questions
- Sensory and Imaginative Immersion 2 questions
- Flow: 2 questions
- Tension: 2 questions
- Challenge: 2 questions
- Negative affect 2 questions
- Positive affect: 2 questions

Post-Game Module

- Positive experience: 6 questions
- Negative experience: 6 questions
- Tiredness: 2 questions
- Return to reality: 3 questions

The competence component describes how skillful a player felt. The two metrics for immersion and flow are not to be confused. The immersion metric has to do with the imaginative aspect, while the flow metric has to do with how much the player forgot the world around them. The tension metric described the annoyance a player experienced. The negative and positive affect measures are more trivial, and give a more general indication of the game experience.

The origins of the game experience metrics are described in more detail in the background relating to game experience evaluation.

Stage 4: Open questions

Apart from the quantitative data collection, three questions were asked to prompt the participants to elaborate on their gameplay experience. The first question was whether or not the leap motion was tiring/heavy to use, and, the second question was whether they would use the leap motion for daily activities. The participants were also asked whether they do sports (inquiring about their kinesthetic qualities). Some general indications of the players' game experience could be gained from the elaborations relating to the outcomes of the quantitative analysis.

6

Results

- Game Experience
- Gameplay Behavior
- Hypothesis Test

In this chapter the results of the experiment are discussed, and the hypothesis test is performed.

6.1 Game Experience

The participants were sufficiently immersed, and experienced flow. Observing the participants during the gameplay session indicated that participants were focused, since none of the participants interrupted the gameplay until the game session was done. All participants managed to finish the entire game session within the maximum amount of time (25 minutes).

Both a qualitative and a quantitative descriptive analysis were performed. The quantitative analysis was performed on the gameplay behavior measures, as well as on the GEQ results.

The results of the GEQ revealed several differences between the kinesthetic and non-kinesthetic participants. They are discussed in the next sections.

Core module

As seen in the Core module results (Chart 1), both the kinesthetic and non-kinesthetic participants had a positive experience, and indicated an above average level of flow. The kinesthetic participants scored very low on the tension variable. This variable has to do with the level of frustration the player experienced. All GE factors suggest that the kinesthetic players had a better game experience than the non-kinesthetic players.

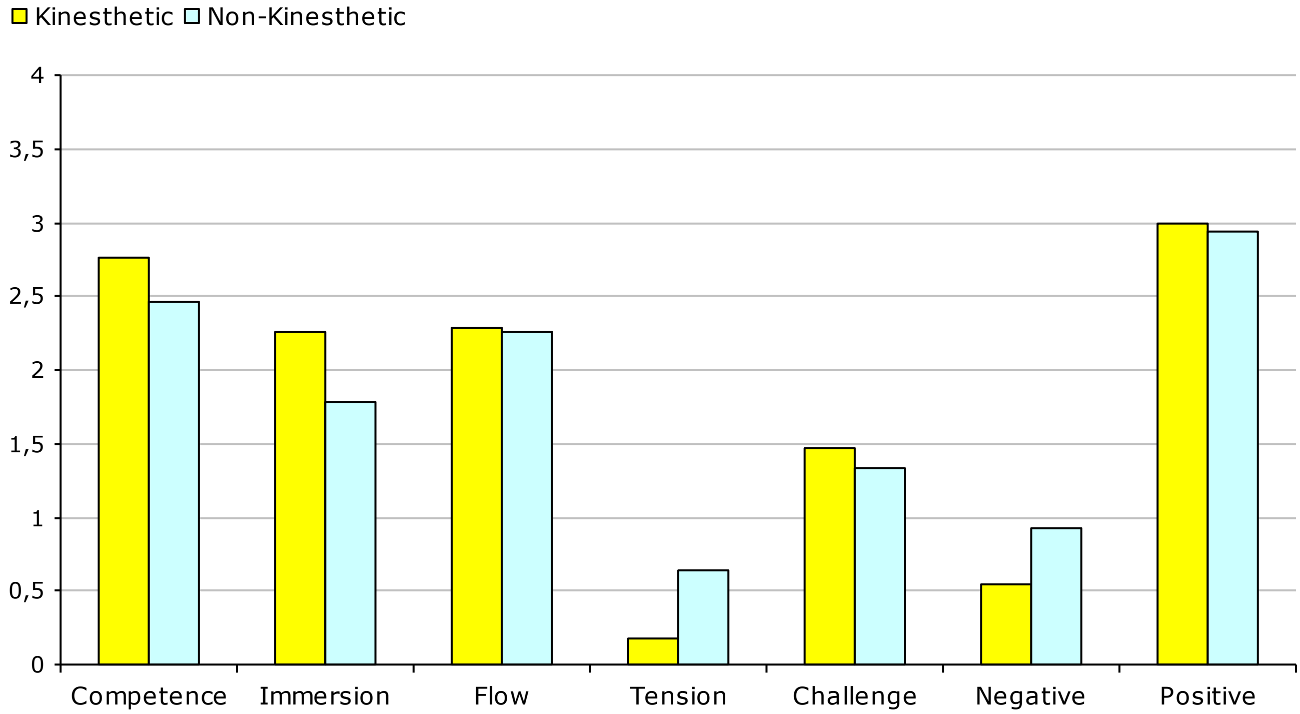


Chart 1 Game experience: core module

An independent-samples *t*-test performed on the core module metrics showed that there were significant differences between the two groups for the competence, tension, and negative affect GE factors (see Table 3). Equal variance was assumed. Significant p-values are marked ($p < 0{,}05$).

	Kinesthetic		Non-kinesthetic		T-Test
Core - GE Factor	Mean	SD (σ)	Mean	SD (σ)	*p*-value
Competence	2,763	0,250	2,460	0,365	0,037
Immersion	2,255	0,960	1,787	0,864	0,257
Flow	2,291	0,817	2,260	0,737	0,929
Tension	0,181	0,273	0,633	0,618	0,040
Challenge	1,472	0,840	1,340	1,34	0,661
Negative Affect	0,545	0,400	0,925	0,355	0,034
Positive Affect	3,000	0,544	2,940	0,542	0,803

Table 3 Game experience: t-tests core module

In-game module

For the in-game module results the same pattern was observed, but with larger differences between the two groups (see Chart 2). The kinesthetic players indicated they had a very positive experience, with very low levels of tension/annoyance.

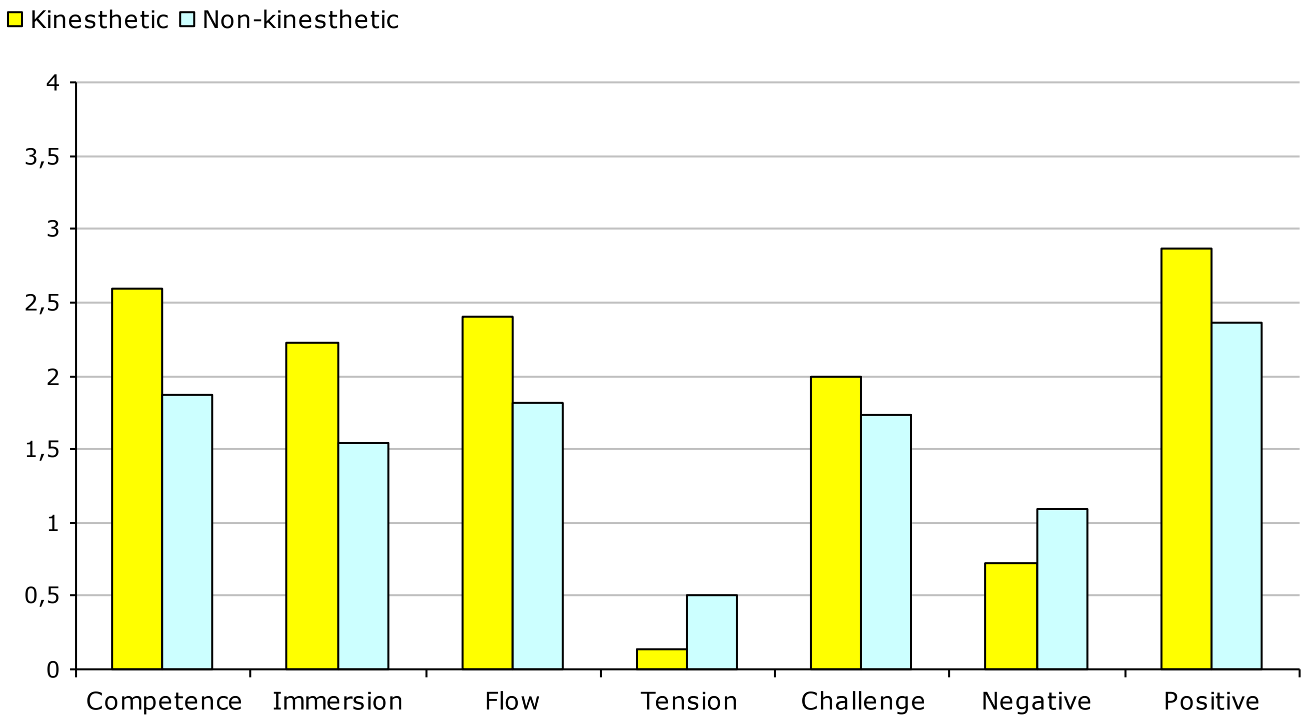


Chart 2 Game experience: in-game module

In the independent *t*-test results for the in-game module significant differences were observed for the immersion and tension GE factors (see Table 4).

	Kinesthetic		Non-kinesthetic		T-Test
IG - GE Factor	Mean	SD (σ)	Mean	SD (σ)	*p*-value
Competence	2,591	0,437	2,350	0,474	0,241
Immersion	2,227	0,720	1,550	0,599	0,031
Flow	2,409	1,261	1,850	0,883	0,259
Tension	0,136	0,234	0,500	0,408	0,020
Challenge	2,000	0,922	1,900	0,516	0,766
Negative Affect	0,7272	0,817	0,900	0,775	0,626
Positive Affect	2,864	0,710	2,700	0,350	0,518

Table 4 Game experience: t-tests in-game module

Post-game module

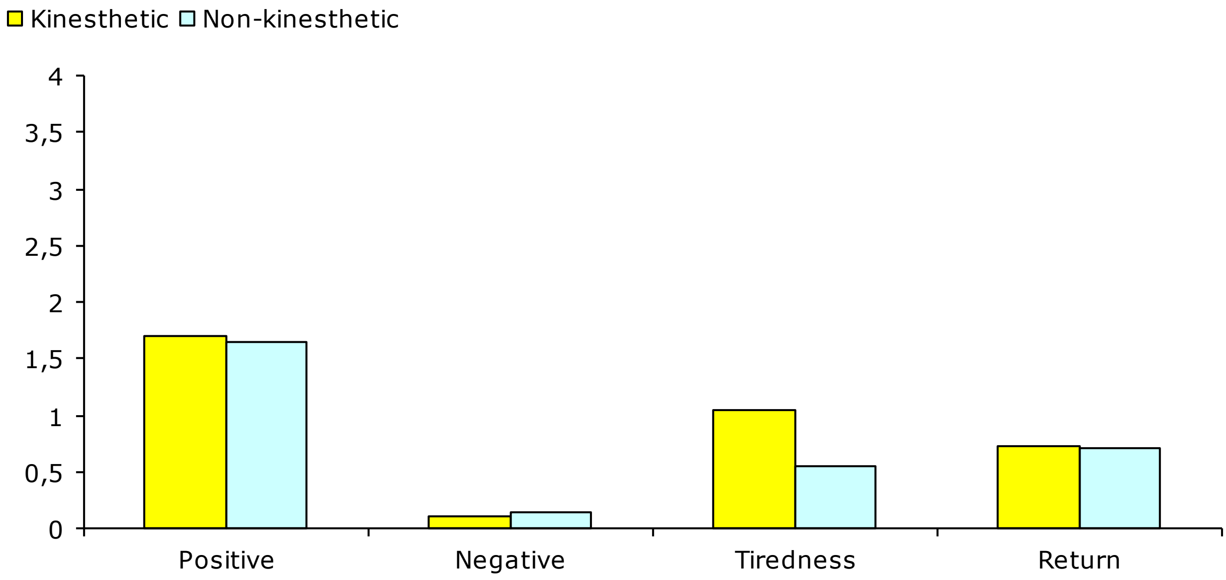


Chart 3 Game experience: post-game module

In the post-game module, an unexpected result was observed (see Chart 3), which had to do with the tiredness of the players. The kinesthetic participants seemed to feel more tired after they finished playing than the non-kinesthetic group. The players were asked about this phenomenon during the open question sessions, and 8 out of 11 kinesthetic players reported feeling physically tired, compared to only 3 out of 11 non-kinesthetic players. Many of the participants that felt tired after the game session explained that it was because of the positions in which they had to keep their arms while playing. The post-game module revealed no significant differences between the two groups (see Table 5).

	Kinesthetic		Non-kinesthetic		T-Test
PG - GE Factor	Mean	SD (σ)	Mean	SD (σ)	*p*-value
Positive	1,697	0,868	1,650	0,487	0,487
Negative	0,106	0,250	0,150	0,146	0,633
Tiredness	1,045	1,254	0,550	0,864	0,309
Return	0,727	0,975	0,700	0,692	0,942

Table 5 Game experience: t-tests post-game module

6.2 Gameplay Behavior

Several aspects of the logged data have to be taken into account. Since the sample size was limited, it was hard to indicate significant differences between the two groups (see graph 1, 2). Since the first difficulty was considered a training stage (in which there were significant outliers), separate observations will be made for difficulty 2 and 3.

Several derived variables were conceptualized, after which a few specific variables were determined to be the most significant supporting claims on game experience; the off percentage, a measure that describes inaccuracy, and the average cell time. Their definition is as follows:

$$Off\ percentage = \frac{Cells\ visited - Distance\ to\ target}{Distance\ to\ target} \times 100\%$$

$$Average\ cell\ time = \frac{Time}{Cells\ visited}$$

Within the kinesthetic group correlations were found between challenge and off-percentage, as well as tension, and positive post-game affect. For the non-kinesthetic group inverse correlations were found between off-percentage and competence, as well as negative affect (see table 6).

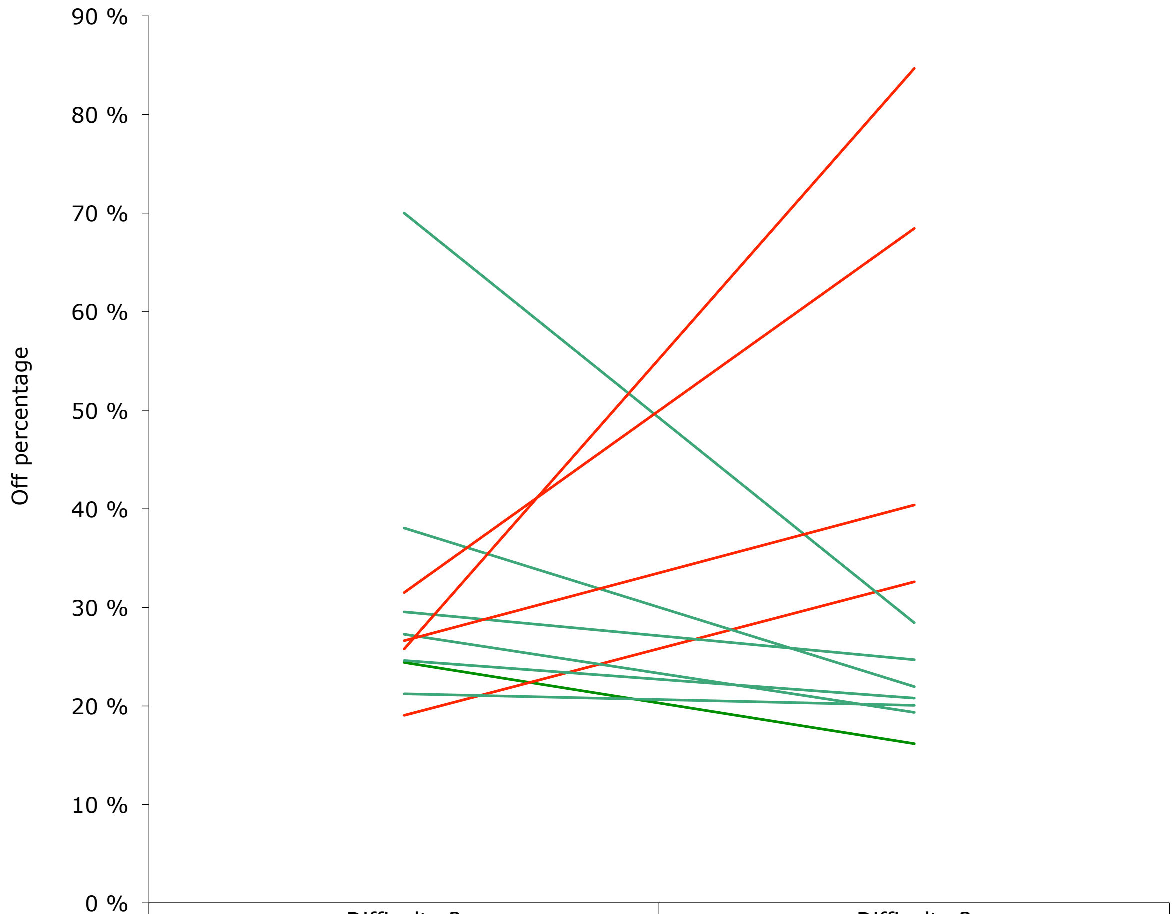
The increase in off percentage from difficulty 2 to 3 correlated to core-challenge, in-game tension and post-game positive affect. The off percentage change between difficulty 2 and 3 is related to how players dealt with the introduction of obstacles.

Overall the game experience outcomes for the two groups respond very differently to higher measures of inaccuracy. Where the kinesthetic players indicate they felt more challenged, the non-kinesthetic players indicated they felt less competent and less positive.

	Kinesthetic				Non-kinesthetic			
GE Factor	Off % Mean	Off % 2 – 3	Cell Time Mean	Cell Time 2 – 3	Off % Mean	Off % 2 – 3	Cell Time Mean	Cell Time 2 – 3
Core Competence	0,444	0,143	0,268	0,154	-0,458	-0.654*	0,049	0,134
Core Immersion	0,558	0,600	0,462	0,370	-0,279	-0.137	0,108	0,259
Core Flow	0,320	0,562	0,073	-0,111	0,018	-0.138	-0,358	-0,396
Core - Tension	0,190	0,344	0,011	-0,75	0,162	0.186	0,552	0,651*
Core Challenge	0,712*	0,753**	0,397	-,226	-0,048	-0.57	-0,244	-0,215
Core Negative	0,420	0,346	0,319	0,233	-0,010	0.0	0,170	0,346
Core Positive	-0,189	0,253	-0,184	-0,311	-0,580	-0.682*	-0,480	-0,396
In-game Competence	0,224	0,272	-0,19	-0,147	-0,314	-0.532*	-0,220	-0,262
In-game Immersion	0,084	0,271	0,425	0,382	-0,510	-0.434	-0,128	0,026
In-game Flow	0,332	0,387	0,396	0,321	-0.178	-0.136	-0,019	-0,145
In-game Tension	0,452	0,645*	0,258	0,130	0.192	-0.068	0,266	0,240
In-game Challenge	0,562	0,525	0,378	0,265	-0,365	-0.475	-0,603*	-0,632*
In-game Negative	0.339	0,414	0,174	0,090	0.195	0.147	-0,362	0,350
In-game Positive	-0,164	0,220	-0,047	-0,212	-0.550	-0.531*	-0,220	-0,056
Post-game Positive	0,595	0,741**	0,339	0,203	-0,409	-0,334	-0,243	-0,032
Post-game Negative	0,110	-0,370	0,046	0,198	0,530	-0,656*	0,539	0,393
Post-game Tiredness	0,440	0,542	0,257	0,123	-0,116	-0,158	0,227	0,369
Post-game Return	0,412	0,364	0,608*	0,479	-0,25	0,199	-0,162	-0,147

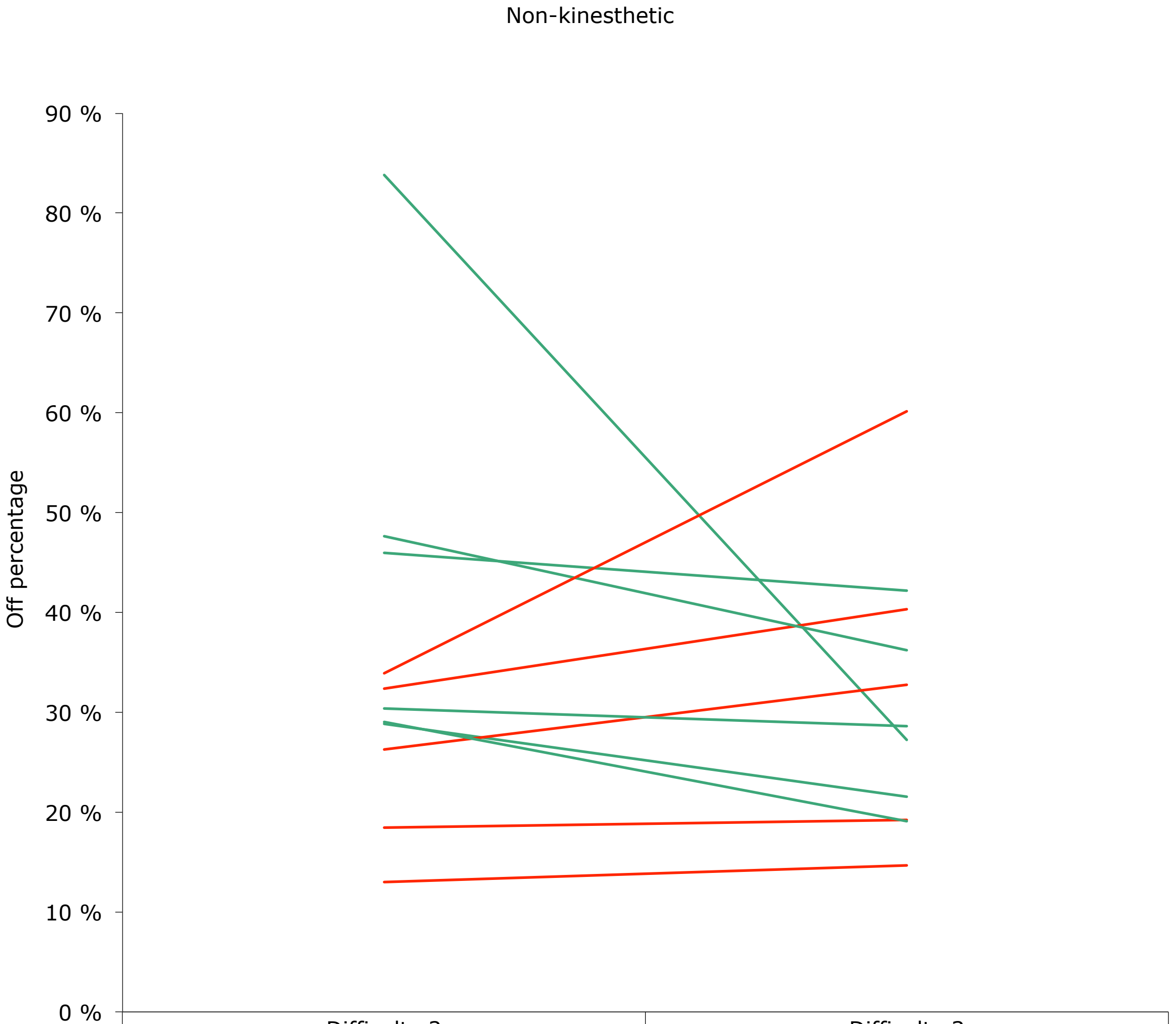
Table 6 Gameplay behavior: correlation analysis

Kinesthetic



	Difficulty 2	Difficulty 3
1	24,40518867	16,14797667
2	19,02461333	32,56136
3	24,56703667	20,769691
4	69,97204	28,40859333
5	21,20018667	20,01774333
6	38,02438	21,93558333
7	27,25652667	19,32301667
8	31,48071333	68,39663667
9	29,51352333	24,66559333
10	25,75320333	84,64031
11	26,58008667	40,34391333

Graph 1 Off percentage progression for kinesthetic players



	Difficulty 2	Difficulty 3
1	12,974228	14,686145
2	28,83731	21,54571667
3	83,79631	27,22222333
4	32,35042667	40,31986667
5	26,25842667	32,74828667
6	18,42825333	19,20875433
7	47,63929	36,19745333
8	45,97605333	42,16450333
9	30,38996333	28,61090333
10	29,04483333	19,09074667
11	33,89272	60,1545

Graph 2 Off percentage progression for non-kinesthetic players

6.3 Hypothesis Test

The hypothesis "*People with a high bodily-kinesthetic intelligence will have a better gameplay experience playing the Maze Balancer game.*" is accepted based on the results on all GE factors. Significant game experience differences, in favor of better gameplay experience for kinesthetic players, were found between in both the core module and in the in-game module. None of the game experience factors indicated a better game experience for non-kinesthetic players.

7

Conclusions

7.1 Summary

In this thesis the potential for a player-centered game design method for serious games was analyzed on the basis of an experiment. For the experiment a game was developed with assumed kinesthetic qualities. Participants generally enjoyed the game, showing highly positive game experience results overall. Results also show that the game was favored by kinesthetic players. Significantly different game experience outcomes for kinesthetic players compared to non-kinesthetic were found, confirming the hypothesis.

7.2 Contributions

The game experience results, as well as the gameplay behavior correlations suggest that MI theory can be a good basis for defining a player typology, since the two groups had significantly different game experiences. In other words: the MI theory provides a good way to differentiate between players for player-centered game design. This is important to know in the context of serious games, because game experience has a strong connection to learning outcomes.

7.3 Limitations

No general conclusions can be made on gameplay behavior in relation to game experience or learning, since our gameplay behavior measures are game specific. Defining general gameplay behaviors is difficult since games may widely differ from each other. However, standardized gameplay behavior measures could be established for specific genres of games. In other words, some

7.4 Suggestions for Future Work

Even though gameplay behavior measures are often game specific, genre-specific gameplay behavior measurements can apply to a large portion of games. When relations would be found between game experience outcomes, and genre-specific gameplay behavior measures, designers can avoid the gameplay behaviors that would cause negative effects for the players they are targeting in their designs.

Another possibility for a larger-scale study would be to see how the MI theory based player-centered game design affects the affinity spaces. In other words, would players with a targeted MI profile be more involved in the affinity space then players with other MI profiles.

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Appendix A: Multiple Intelligences Questionnaire

Please answer these questions on the specified scale

1. Writing is a natural way for me to express myself.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

2. At school, studies in native language were easy for me.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

3. I have recently written something that I am especially proud of, or for which I have received recognition.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

4. Metaphors and vivid verbal expressions help me learn efficiently.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

5. At school, I was good at mathematics, physics or chemistry.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

6. I can work with and solve complex problems.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

7. Mental arithmetic is easy for me.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

8. **I am good at games and problem solving, which require logical thinking.**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

9. **At school, geometry and various kinds of assignments involving spatial perception were easy for me.**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

10. **It is easy for me to conceptualize complex and multidimensional patterns.**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

11. **I can easily imagine how a landscape looks from a bird's eye view.**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

12. **When I read, I form illustrative pictures or designs in my mind.**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

13. **I am handy.**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

14. **I can easily do something concrete with my hands (e.g. knitting and woodwork).**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

15. **I am good at showing how to do something in practice.**

○—○—○—○—○
Strongly agree | Agree | I don't know | Disagree | Strongly disagree

16. **I was good at handicrafts at school.**

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

17. After hearing a tune once or twice I am able to sing or whistle it quite accurately.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

18. When listening to music, I am able to discern instruments or recognize melodies.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

19. I can easily keep the rhythm when drumming a melody.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

20. I notice immediately if a melody is out of tune.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

21. Even in strange company, I easily find someone to talk to.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

22. I get alone easily with different types of people.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

23. I make contact easily with other people.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

24. In negotiations and group work, I am able to support the group to find a consensus.

Strongly agree | Agree | I don't know | Disagree | Strongly disagree

25. I am able to analyze my own motives and ways of action.

Strongly agree — Agree — I don't know — Disagree — Strongly disagree

26. I often think about my own feelings and sentiments and seek reasons for them.

Strongly agree — Agree — I don't know — Disagree — Strongly disagree

27. I spend time regularly reflecting on the important issues in life.

Strongly agree — Agree — I don't know — Disagree — Strongly disagree

28. I like to read psychological or philosophical literature to increase my self-knowledge.

Strongly agree — Agree — I don't know — Disagree — Strongly disagree

29. I enjoy the beauty and experiences related to nature.

Strongly agree — Agree — I don't know — Disagree — Strongly disagree

30. Protecting the nature is important to me.

Strongly agree — Agree — I don't know — Disagree — Strongly disagree

31. I pay attention to my consumption habits in order to protect environment.

Strongly agree — Agree — I don't know — Disagree — Strongly disagree

Game Experience Questionnaire – Core Module

Please indicate how you felt while playing the game for each of the items, on the following scale:

not at all	slightly	moderately	fairly	extremely
0	1	2	3	4
< >	< >	< >	< >	< >

1 I felt content
2 I felt skilful
3 I thought it was fun
4 I was fully occupied with the game
5 I felt happy
6 It gave me a bad mood
7 I thought about other things
8 I found it tiresome
9 I felt competent
10 I thought it was hard
11 It was aesthetically pleasing
12 I forgot everything around me
13 I felt good
14 I was good at it
15 I felt bored
16 I felt successful
17 I felt imaginative
18 I felt that I could explore things
19 I enjoyed it
20 I was fast at reaching the game's targets
21 I felt annoyed
22 I felt pressured
23 I felt irritable
24 I lost track of time
25 I felt challenged
26 I found it impressive
27 I was deeply concentrated in the game
28 I felt frustrated
29 It felt like a rich experience
30 I lost connection with the outside world

31 I felt time pressure
32 I had to put a lot of effort into it

In-game GEQ

Please indicate how you felt while playing the game for each of the items, on the following scale:

not at all	slightly	moderately	fairly	extremely
0	1	2	3	4
< >	< >	< >	< >	< >

1 I felt successful
2 I felt bored
3 I found it impressive
4 I forgot everything around me
5 I felt frustrated
6 I found it tiresome
7 I felt irritable
8 I felt skilful
9 I felt completely absorbed
10 I felt content
11 I felt challenged
12 I had to put a lot of effort into it
13 I felt good

GEQ – post-game module

Please indicate how you felt after you finished playing the game for each of the items,
on the following scale:

not at all	slightly	moderately	fairly	Extremely
0	1	2	3	4
< >	< >	< >	< >	< >

1 I felt revived
2 I felt bad
3 I found it hard to get back to reality
4 I felt guilty
5 It felt like a victory

6 I found it a waste of time
7 I felt energised
8 I felt satisfied
9 I felt disoriented
10 I felt exhausted
I felt that I could have done more
11 useful things
12 I felt powerful
13 I felt weary
14 I felt regret
15 I felt ashamed
16 I felt proud
I had a sense that I had returned from
17 a journey