4-2017

An Immersive Learning Model

Shamsa Abdulla Salem Al Mazrouei

United Arab Emirates University

College of Information Technology

Department of Computer Science and Software Engineering

AN IMMERSIVE LEARNING MODEL

Shamsa Abdulla Salem Al Mazrouei

This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Science in Software Engineering

Under the Supervision of Professor Boumediene Belkhouche

April 2017

Declaration of Original Work

I, Shamsa Abdulla Salem Al Mazrouei, the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this thesis entitled *"An Immersive Learning Model"*, hereby, solemnly declare that this thesis is my own original research work that has been done and prepared by me under the supervision of Professor Boumediene Belkhouche, in the College of Information Technology at UAEU. This work has not previously been presented or published, or formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my thesis have been properly cited and acknowledged in accordance with appropriate academic conventions. I further declare that there is no potential conflict of interest with respect to the research, data collection, authorship, presentation and/or publication of this thesis.

Student's Signature:  Date: 22/Jun/2017

Advisory Committee

1) Advisor: Boumediene Belkhouche

Title: Professor

Department of Computer Science and Software Engineering

College of Information Technology

2) Member: Mamoun Awad

Title: Associate Professor

Department of Computer Science and Software Engineering

College of Information Technology

3) Member: Abderrahmane Lakas

Title: Associate Professor

Department of Computer and Network Engineering

College of Information Technology

Approval of the Master Thesis

This Master Thesis is approved by the following Examining Committee Members:

1) Advisor (Committee Chair): Boumediene Belkhouche

Title: Professor

Department of Computer Science and Software Engineering

College of Information Technology

Signature _____ Date Apr 26, 17

2) Member: Saad Harous

Title: Associate Professor

Department of Computer Science and Software Engineering

College of Information Technology

Signature _____ Date 26/4/2017

3) Member (External Examiner): Mohammad Hamdan

Title: Associate Professor

School of Mathematical and Computer Sciences

Institution: Heriot-Watt University, Academic City, Dubai

Signature Mohammad Hamdan Date 26/4/2017

This Master Thesis is accepted by:

Dean of the College of Information Technology: Professor Omar El-Gayar

Signature _____ Date July 5, 2017

Dean of the College of Graduate Studies: Professor Nagi T. Wakim

Signature _____ Date 5/7/2017

Copy 4 of 6

Approval of the Master Thesis

This Master Thesis is approved by the following Examining Committee Members:

1) Advisor (Committee Chair): Boumediene Belkhouche

Title: Professor

Department of Computer Science and Software Engineering

College of Information Technology

Signature _____ Date _____

2) Member: Saad Harous

Title: Associate Professor

Department of Computer Science and Software Engineering

College of Information Technology

Signature _____ Date _____

3) Member (External Examiner): Mohammad Hamdan

Title: Associate Professor

Mathematical and Computer Sciences

Institution: Heriot-Watt University, Academic City, Dubai

Signature _____ Date _____

Abstract

Our overarching goal is to provide children with immersive game-based learning environments to support Arabic linguistic skills acquisition. We postulate that immersion increases learning. To investigate this hypothesis, we developed a model and built an implementation of an educational virtual environment (EVE) that supports immersion and thus, induces effective learning. Experimental results confirm our hypothesis.

Our model integrates learning content, learning activities, immersion and gameplay. Based on our analysis of various curricula, specifically the United Arab Emirates grade one curriculum, we identified the nature of the learning content in order to satisfy the curriculum requirements. This content is conceptually structured to support gradual and independent learning. Acquiring knowledge from the learning content involves a learning process that we operationalize as a set of well-defined cognitive activities, which are categorized as perception, recognition, association, composition and recall. Accordingly, gameplay events and actions are designed to afford and instantiate these activities to engage the learner. Besides gameplay, engagement is explicitly addressed by modeling immersion using three different dimensions (sensory, imaginative and challenge-based).

Our implementation is a 3D virtual reality game that captures various learning environments, each of which provides adventure, exploration, and learning. The gameplay engages players into learning activities that stimulate their senses, challenges them, and keep them absorbed in their quests. The implemented system runs on PC's with Occulus and on smart phones with virtual glasses. These configurations were used in experiments in the laboratory, at a primary school, and in informal settings to measure immersion and learning. Results show that our model contributes effectively to immersion and learning.

Keywords: Game-based learning, educational games, immersive worlds, virtual reality, virtual reality glasses, wearable devices, immersion, engagement, effect size.

Title and Abstract (in Arabic)

نموذج للتعلم الغامر

الملخص

هدفنا الرئيسي هو تزويد الأطفال بألعابٍ تعليمية تمكنه من الاندماج في بيئة اللعب لمساعدته على اكتساب المهارات اللغوية المتعلقة باللغة العربية. قمنا بافتراض أن عملية الدمج تساعد على زيادة كفاءة التعلم. و لإثبات هذه الفرضية لجعلها نظرية، عملنا على تطوير نموذج و بناء بيئة تعليمية افتراضية تدعم عملية الدمج في بيئة اللعب، و منها، تحث على التعلم الفعّال. نتائج التجارب التي أجريناها تثبت الفرضية التي افترضناها.

النموذج الذي طورناه يجمع بين المحتوى التعليمي، و الأنشطة التعليمية، عملية الدمج، و طريقة اللعب. بالاعتماد على تحاليلنا لمختلف المناهج، و تحديداً منهج الروضة لدولة الإمارات العربية المتحدة، قمنا بتعريف طبيعة المحتوى التعليمي بما يتماشى مع متطلبات و أهداف المنهج. تم تشكيل هذا المحتوى لدعم التعلم المتدرّج و الذاتي. اكتساب المعرفة من المحتوى التعليمي يتضمن عملية تعلّم تم تفعيلها كأنشطة إدراكية، و التي تتضمن الإدراك، التمييز، الربط، التركيب، و التذكّر. و وفقاً لذلك، تم تصميم الأفعال و الأحداث المرتبطة ببيئة اللعب لمنح هذه الأنشطة التي تساهم في دمج المتعلّم. بالإضافة إلى طريقة اللعب، تم التطرق إلى عملية الدمج بوضوح عن طريق قولبة ثلاثة أبعاد هي، الدمج الحسّي، الدمج الخيالي، والدمج المرتيط بالتحديات.

تطبيقنا هو لعبة تعليمية افتراضية ثلاثية الأبعاد تحتوي على مختلف البيئات التي من خلالها يستطيع اللاعب المتعلّم أن يغامر، يكتشف و يتعلم. طريقة اللعب تقوم بدمج اللاعب بأنشطة التعلّم التي تُحاكي أحاسيسهم، و تضع أمامهم التحاديات، و تجعلهم مندمجين في مهماتهم. تم تصميم النظام للعمل على الحاسب المحمول مع جهاز العالم الافتراضي، كما يعمل على أجهزة الهواتف المحمولة و التي يتم وضعها في نظارات العالم الافتراضي. تم استخدام هذه المعدات في التجارب التي أجريناها في المختبرات و صفوف الروضة من أجل قياس معدّل التعلم و الدمج لدى اللاعب المتعلّم. و أظهرت النتائج بأن النموذج الذي قمنا ببناءه يساهم على التعلم و الدمج في بيئة اللعب بشكل فعّال و ملحوظ.

مفاهيم البحث الرئيسية: التعلم عن طريق اللعب، الألعاب التعليمية، البيئات الافتراضية، العالم الافتراضي الحقيقي، نظارات العالم الافتراضي، أجهزة يمكن ارتداؤها، الدمج، الربط، حجم التأثير.

Acknowledgements

I would like to thank my family, my supervisor, my friends and all of those around me who supported me unconditionally throughout my studies.

I would like also to thank the members of my advising committee and the members of the examining committee. I am grateful to them for their feedback and their advice.

Dedication

To my beloved family and teachers

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Motivations

Acquiring solid linguistic skills in early childhood lays the foundations for success at school and in life, for language provides the necessary tools to communicate, share thoughts, and express sophisticated ideas. A mastery of linguistic skills helps the child develop the ability to readily understand and use new concepts and ideas from the various fields of study [1]. Deficiencies in these skills lead to limited comprehension and hinder further intellectual development [2, 3].

Typically, learning is defined as the process of acquiring knowledge, skills, attitudes, and behaviors [4]. However, as reported in [5], the large number of competing learning theories is made more challenging by the complexity of the learning process concept. Some definitions follow. Learning is the process that occurs in an interpersonal and group context, and it is always composed of an interaction of factors to which we append labels such as motivation, cognition, emotion or affect, and attitude [6]. Also, it has been defined functionally as changes in behavior that result from experience or mechanistically as changes in the organism that result from experience. It is also defined as an adaptation, that is, as changes in the behavior of an organism that result from regularities in the environment of the organism[7].

Technology, specifically virtual reality and smart devices and their ubiquitous presence, offers opportunities to support learning resources outside the classroom. Smart devices have grafted themselves into our bodies and our environment at large, thus extending individual and collective capabilities ([8, 9, 10, 11]). Connectivity and accessibility to resources provide users with sophisticated forms of play, communication, collaboration, and knowledge acquisition. In this context, learning in cyberspace (i.e., cyber-learning) has become a pervasive and dominant activity [12]. Cyber-learning promotes constructivism in order to afford learners independence, exploration, self-discovery, and knowledge construction. Consequently, novel models are being proposed to support and enhance the current educational models by integrating technology, learning, and playing, resulting in what is generically termed

“smart learning”. Smart learning provides capabilities to support the learning process through guidance, customization, independent knowledge construction, interactivity, and accessibility [13]. Game-based learning (GBL) is one example of smart learning, which integrates gameplay and explicit learning outcomes. Smart learning aims to have specific, measurable, attainable, relevant, and time-limited learning contents.

The general definition of game-based learning integrates the definitions of two game-related concepts and learning. The first one is “game", which is defined as “Any contest (play) among adversaries (players) operating under constraints (rules) for an objective (winning)” [14]. The second definition introduces the notion of “gameplay”, a fundamental feature of games, which is defined as “the level and the nature of interactivity the game has, i.e, the ability of the player to interact with the game-world and the way the game-world reacts to the decisions the player made” [14]. Thus, GBL is defined as “a computer game-based approach that has the ability to foster the learner who plays to improve his learning motivation and to deliver, support and enhance, teaching, evaluation and assessment” ([15], [16]). GBL uses features of computer and video games in order to create immersive and engaging educational environments to deliver specific outcomes such as events and learning goals [17].

1.2 Literature Review

In this section, we will discuss some different experimental-based researches that have been done to discuss the effects of game-based learning on the learning process.

There is a wide agreement among researchers that games can effectively improve education and be helpful and useful for teaching complex concepts and skills [10]. Several comprehensive meta-analyses demonstrate the positive impact of GBL on learning ([18, 19, 20, 21, 22]). In [18], the authors used meta-analytic techniques to investigate whether serious games are more effective and motivating than instruction-based methods. Their investigation included papers related to game-based learning previous meta-analyses dealing with effectiveness of serious games. Experiments in the analyzed literature collected data on control and experimental groups, whose received the same learning content. Analysis of effect sizes

reported in these experiments confirmed the following hypothesis:

> Serious games support the retention of the material for a long term. Also, instruction with serious games yields higher learning gains in the following conditions:
>
> - Irrespective of whether they are presented alone or supplemented with other instructional methods (but they become less motivating when they are combined with other methods).
> - When they are played in contrast to the mixed instructional method that combines the passive (lectures, PowerPoint presentations, and papers) and the active (with exercises) learning methods together, but not for passive learning or active learning.
> - When they are played in multiple training sessions not only one session.

As stated in [23], when the effect size exceeds the magnitude of 0.25 (a standard value indicates that games are educationally significant), changes in the learning process become noticeable. The results shown in Figure 1.1 of the meta-analysis confirmed that there were significant changes in the performance of the learners as the magnitude was higher than 0.25. Games allow players to acquire new skills, as different kinds of games cover different kinds of themes. In addition, games support the retention of the material for a long time. Also, the learning outcomes and knowledge gained using games are higher compared to the normal instructional methods.

The second meta-analysis study [19] was carried out on on-line instructions research papers to examine the effectiveness of web-based instruction (WBI) in comparison to the class room instruction (CI). The main goal of this study was to assess whether WBI and WBI-S (CI supplemented by WBI) are effective while teaching declarative (passive) and procedural (active) knowledge. The researchers used a multi-dimensional framework of learning that addresses affective, cognitive (facts or definitions) and skill-based (procedural) learning. They compared WBI and WBI-S to CI in terms of their effectiveness for teaching declarative and procedural knowledge. The study reported results which showed that:

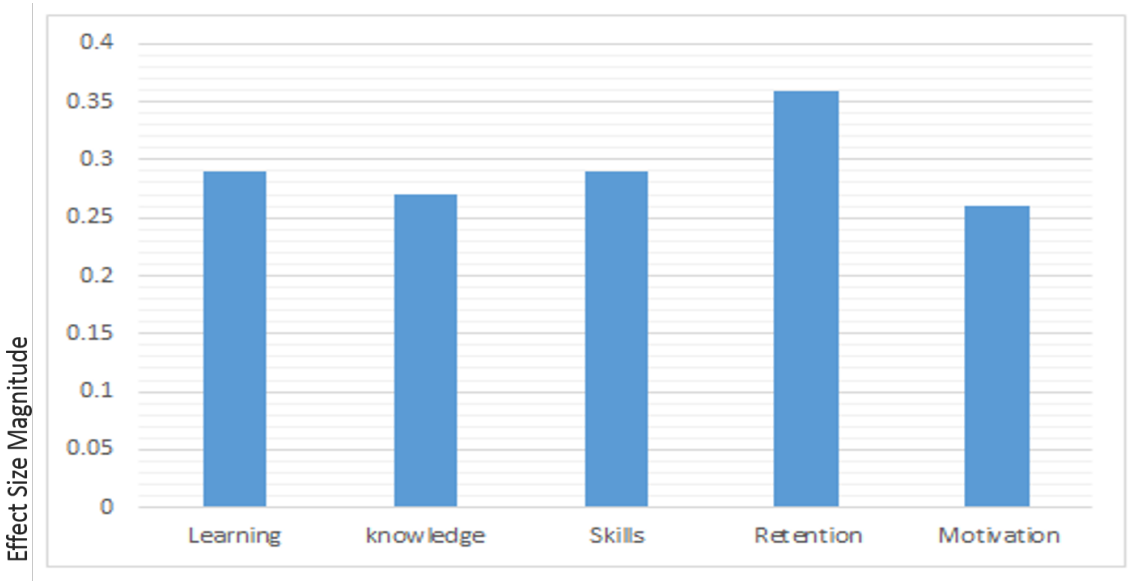


Figure 1.1: Main Effects for Learning, Retention, and Motivation Comparing Series Games with Other Instructional Methods.

- WBI is more effective than CI for teaching declarative knowledge when used with other methods (WBI-S) and when the learners are afforded a high level of control (the extent to which trainees have control over their learning experience by affecting the content, sequence, or pace of material).
- CI is more effective than WBI for teaching declarative knowledge when trainees were randomly assigned to courses.
- WBI and CI are equally effective for teaching procedural knowledge.

A simple goal of GBL is to support the acquisition of knowledge that is comprehensive. As such, it covers learning contents and outcomes from various subjects, such as information technology, engineering, sciences and many others. Players (i.e., learners) are engaged in learning by being challenged to perform a variety of cognitive tasks, such as information collection, analysis, decision-making, reasoning, problem-solving and other physical and intellectual activities. As a simple example, learning the alphabet by children involves interacting explicitly with shapes, sounds, and images, and implicitly with meanings, relationships, and composition. Learners engage in the knowledge acquisition process through pattern recognition, meaning formation, concept association, and concept composition.

Research shows the efficiency of multimedia in supporting learning outcomes, and games are one of the resources that provide multimedia for the players([24]).

The authors performed an experiment on 100 psychology and education students. The subject of the experiment was to understand why there exit time differences among countries. Students were divided into control and experimental groups and were provided with learning material distributed among the two groups, such as in the experimental group included 22 cards (paragraphs) with 2750 words about time and date differences on the earth supported with different kinds of pictures, and in the control group, texts were presented without pictures. A pre-test and a post-test were administered to the students. The pre-test was to assess the students' domain-specific prior knowledge. The post-test given to both groups to assess the extent of the knowledge they acquired.

After calculating the means and standard deviations of the learning outcomes, participants with interactive pictures performed significantly better on the time-difference task than participants with non-interactive pictures.

In [25], the authors tested some games that provide a context supported with sound and images. They studied the effect of three basic properties of sound, which are volume, timing, and source on player engagement. They found that both timed and un-timed sources of sound affect the player senses and feeling, leading to a state of engagement.

Given that motivation is fundamental to any learning activity, the research in [26] identifies some of the game characteristics that contribute to motivation. The author analyzed various educational games and concluded that students are motivated through: competition and goals, as players feel personal attachment to a goal, rules, choice, fantasy, and challenges. In some games the goals are based on competition that if the player wishes to reach the goal he has to compete. For the player to improve their avatar, civilization, business or city, they must complete prerequisites and sub-goals such as beating a non-player character or having a certain number of coins. Such competition motivates the learners to complete the game activities because they want to win.

Rules define constraints that limit the decisions players make while playing. Game rules allow to explore game environments and test hypothesis to fulfill the goals. E.g., if the player hits the right answer he gets points and if he chooses the right path he will survive and vice versa. The degree of flexibility to make decisions and to choose from a variety of paths in order to achieve success helps players develop a knowledge base that is flexible enough to be used in other contexts.

Various types of choices are provided in games. Expressive choices allow the player to improve avatar, city, business and civilization which makes him develop a sense of pride in the accomplishments he made. This can help the learner progress in the game because he wants to improve his avatar. Strategic choices support the ability to change the game attributes, such as the level of difficulty, which help motivate players, because they are given more challenging problems. Tactical choices allow the player to make his own decisions on how to play the game.

In a game, completing some challenges will lead players to more advanced levels that contain complex challenges. This state provides the player with further opportunities to acquire more skills and face greater challenges, thus creating a context that induces a sustained level of motivation.

Fantasy is a reward that is acquired when the player completes successfully a challenge. Fidelity is a type of fantasy. Fidelity can be represented in the game by using graphics, audio and video and virtual worlds which authentically represent reality which can create an exciting and immersive context.

Competition and goals, rules, choices, fantasy, and challenges can be impeded in any game that's promoting motivation.

1.2.1 Educational Games

"Educational games are games that are designed to help people to learn about certain subjects, expand concepts, reinforce development, understand a historical event or culture, or

assist them in learning a skill as they play. Game types include board, card, and video games." [27]

Studies show that educational games are more effective in achieving learning outcomes and can be useful for teaching complex concepts and skills [28]. Baker [29] examined an off-the-shelf flight simulator game in an air crews training. He found that pilots showed positive responses to this type of training, affirming the potential use of the game as a training tool. Gopher and Barket [30] studied the effectiveness of low-fidelity games on learning flight skills. They experimented with a game to train pilots flight skills and the results showed a noticeable increase in the trainees' flight skills.

In our research we analyzed some of what we think are good educational games that teach languages especially Arabic Language.

An educational game called Kios Journey (see Figure 1.2) teaches mathematics for middle school students. It is a 3D computer game that combines learning and playing. Studies to investigate the benefits of the game showed a high impact on students in low-income schools in New Mexico (USA).

Figure 1.2: Kio's Journey Game

Figure 1.3 shows the results of this study conducted on a population of 5^{th} to 8^{th} grade students between 2004-2007 assess to their proficiency in mathematics. Students were divided into two groups: one followed the normal teaching methods and the other group engaged in a math game. As the chart shows, students who used math games in their study (gray) acquired a higher proficiency level compared to the other group who did not use math games (brown).

Such a study demonstrates that games can help in teaching and improving students educational levels.

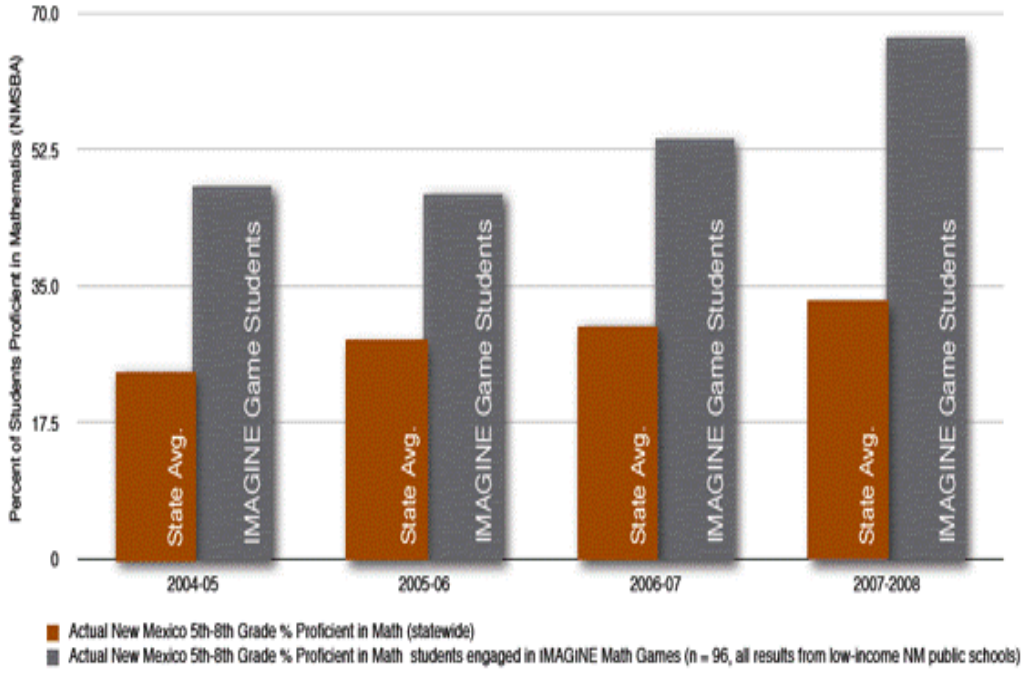


Figure 1.3: Relation Between Math Games and Students Performance in Mathematics

Another game is (ABC Alphabet Puzzles). It is deployed on Apple tablets and is an educational game that teaches English basics for preschool children from 2 to 6 years old. It teaches the alphabet from A to Z. Also, it teaches new words, shapes and spelling. ABC Alphabet Puzzles is a static game and has a cartoonish presentation, which we think attracts the attention of the child.

Figure 1.4: ABC Alphabet Puzzles Game

Noor Al Bayan is a program for teaching children Arabic language with inspiration from the Holy Quran. It is a static computer game that teaches the Arabic alphabet with sounds, Arabic basics, and words.

Figure 1.5: Noor Al Bayan Game

Another game for teaching Arabic language is Arabic School. This game teaches the Arabic language for non-Arabic people. It teaches the letters, the sounds, and some Arabic words.

Unfortunately, there are not enough good games for learning the Arabic language and the available ones miss the fun part and have low effectiveness in teaching the Arabic language. This is because of the lack of interest in developing such games and most of the developers cannot integrate entertainment and language learning. This can be obvious in the games we found in the Apple store for example. In the Apple applications store, we notice a clear shortage in the games that teach Arabic language. Also the games that are available have no balance between entertainment and the learning material represented.

Figure 1.7 shows examples of some educational games that teach Arabic language.

Figure 1.6: Arabic School Game.

1.2.2 Immersion and Immersive Educational Games

The advantage of utilizing technological tools to support learning is that learners are exposed to various modalities (visual, auditory, and tactile). Not only multimodal presentations, such as virtual reality, enhance the learning process, they also motivate and engage the learner [31]. Various research experiments to assess the impact of virtual reality on the brain have been reported.

From an operational perspective, the learning process is considered as a set of activities that involve recognizing, perceiving, debriefing, recalling, locating, and classifying the learning context [32]. One way to foster the learning process, including its cognitive activities, is to provide an immersive environment where the learner participates in a comprehensive, realistic experience, and is motivated and engaged totally in the learning process [33]. Interactive media, such as virtual reality, support various degrees of digital immersion which provides an escape for the players from everyday life. Studies show that immersion enhances

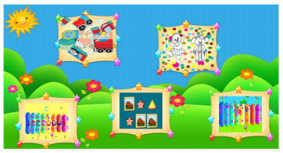
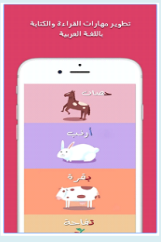
Game	Description	Snapshoot
	This application is for teaching kids the Arabic alphabets, using 28 human and animal characters with voices. It covers the alphabet, characters , and coloring.	
	Kalematy. The game teaches children from the age of 3-5 years the Arabic letters and the combination of letters into words. The application has five educational groups, which are animals, plants, food , at school and at home. In addition, it has a coloring section.	
	This application is for teaching kids the Arabic alphabet and how to write it. The child first chose the letter to hear the sound, then he/she can see the animals which start with this letter. Also the game teaches how to write the letters.	
	The game teaches children how to learn and distinguish different objects, sounds, alphabet and colors using drag and drop picture and their names. It also has a coloring section.	
	This game application shows children how the Arabic alphabets are pronounced with presenting its sound and shape. Also, it presents some small games that has nothing to do with learning (e.g. a piano to play music).	
	This game represents the alphabets with their sounds and shapes. Also, it displays some pictures of objects related to the presented alphabets. And it contains some Arabic songs related to the Arabic alphabets.	
	This game application presents some of the Arabic alphabets shapes, and how they are pronounced. Also, it contains some songs related to the alphabets.	
	Lamsa is an educational application that teaches the child the concepts of animals, family and friends, colors in addition to alphabets and numbers. The material is presented as songs only.	

Figure 1.7: Children Educational Games

education in three ways: allowing multiple perspectives, suitable learning, and learning transfer [33]. Games do provide immersive contexts that monopolize the senses, engage the player psychologically and require physical actions [25].

One of the major characteristics of video games that is highlighted in the studies we reviewed is their ability to create an immersive experience [34]. Immersion is the perception of game's reality, the degree of focus, the feel of presence, involvement, and engagement in this reality [35]. It is an outcome of a deep, yet effortless, involvement, feel of control, flow state, and enjoyment [34]. Each one of these components and outcomes are explained as follows:

- Control is the extent to which the player feels empowered to create changes in the game environment and his ability to influence the game environment and to manipulate the game and make their intent manifest [36].
- Flow is an experience resulting in intense engagement, heightened motivation, receptiveness to information, and diminished perception of time. And it is an outcome of the ability to concentrate on the task, clear task goals, immediate feedback, a sense of control over actions, deep but effortless involvement, loss of concern for self, and an altered sense of time [35].
- Involvement is an element that requires a task to accomplish, and an unimpeded ability to concentrate on this task and its an outcome of having control in the game [37].
- Presence refers to the temporary acceptance of a game's reality over the real world, and is characterized by the feeling of being there [34].
- Engagement refers to deep involvement with a game and it stems from gameplay rather than narrative or sensory stimuli [34].

Immersion, as an element included in virtual educational games, has the ability to support effective learning [38], [39], [40], [41], [35], [42], [43].

The research in [44] proposed a game experience model called CSI model which

claims that there are three key dimensions that contribute to immersion. These are: (1) imaginative immersion; (2) challenge based immersion; and (3) sensory immersion.

To test the model and examine how the different aspects of immersion appear in the game, the researchers conducted an experiment, inn which participants aged between 12 and 40 years old played some games with PC computers and other games with PlayStation 2. They invited players who play popular games to evaluate their experiences of these games. The games were chosen depending on two factors: the researchers tried to cover as wide a range of different genres as possible, and they chose the games that are played the most among the players. The researchers constructed a questionnaire of thirty questions that address the three dimensions of immersion (the sensory, the imaginative, and the challenge based immersion) and response given in a 5-point Likert scale. The scale of the sensory immersion contained questions related to the capturing of the senses done by the game. The scale of challenged-based immersion contained questions related to flow-like experiences (e.g. “the game challenged me to strive to the limits of my abilities"). The scale of imaginative immersion measured how the player was involved in the game.

After analyzing the data of the questionnaire, the researchers found that the results support the SCI-model and all the games supported immersion but each one of them promoted one kind more than the others. Figure 1.8 shows the results of the questionnaire.

The authors in [43] designed a virtual world platform called virtUAM to explore the educational and motivational potential of virtual worlds in combination with game like applications. After the experience they did, they found that games facilitate and foster the learning process, the immersive environments and presenting vocabularies in a context facilitates the understating and the learning processes. Also, they found that game features such as competition motivates students to be more active and makes them challenge themselves to win the game and the subjects of the experiment said educational games provide many opportunities for interaction.

The authors in [38] developed a tool called System of Augmented Reality for Teach-

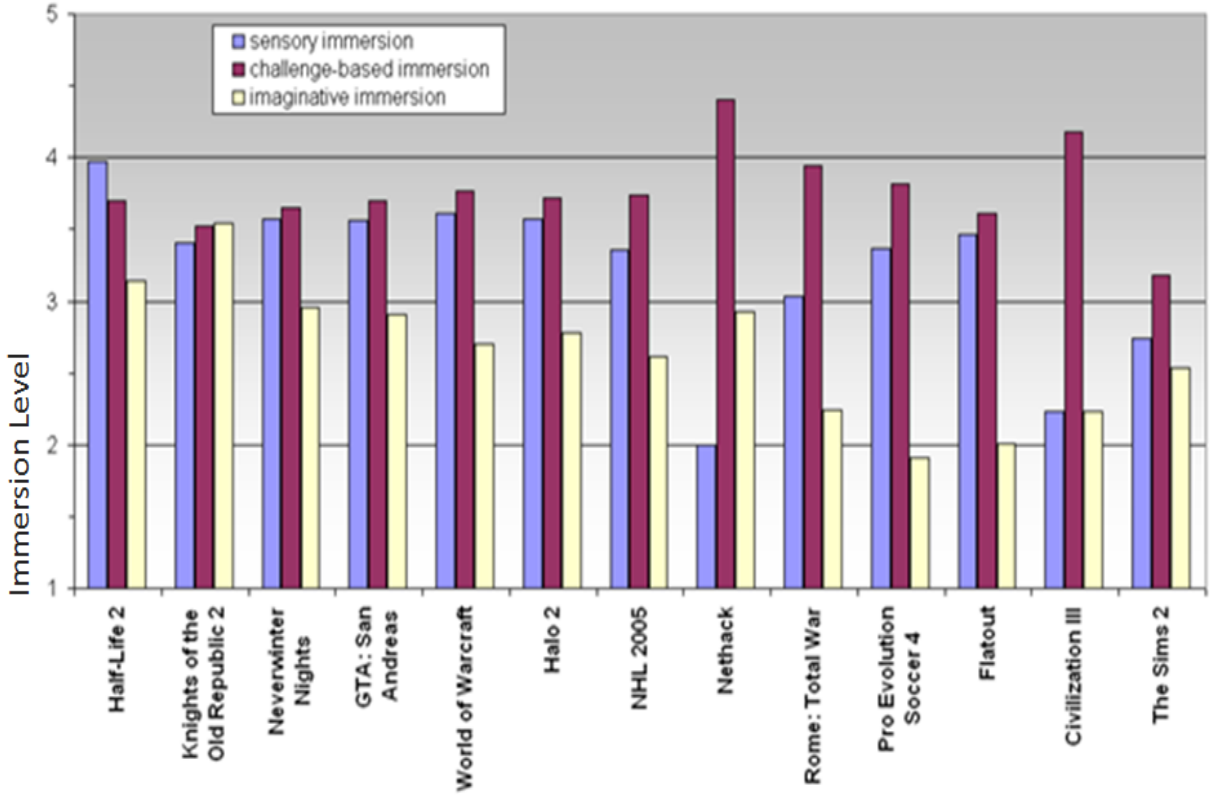


Figure 1.8: The Average Amount of Each Immersion Type Reported by the Players in Different Digital Games

ing (SMART) that was shown to be an effective tool in maintaining high levels of motivation among children, and also that SMART has a positive impact on the student learning experience, especially among the weaker students.

The experiment was conducted in three schools, it contained a control group and an experimental group. Each group was given a pre-test, a post-test, and an augmented session. The control group held a traditional learning session while the experimental group started with the students trying SMART system. While using SMART, the students were videotaped. The researchers analyzed all the recorded videos to gather the results on motivation levels and students' reactions while using SMART. The experimental group performed a pretest and the average degree gained by each group is calculated by the following formula: <g> = (post-test in the post-test and pretest percentage is the percentage of correct answers in the pretest.

The results from the experiment done on the students using SMART showed that

the evolution in the learning process of the experimental group is higher in comparison to the control group. Also, it's been noticed that the virtual worlds are powerful in triggering, initiating and sustaining motivation in the immersive virtual environment among the students. Moreover, the researchers concluded that AR (Augmented reality) combines the visual and the sensory information, which support the cognitive and learning experience that changes the way the content is understood. Figures 1.9 and 1.10 show the results of SMART experiment.

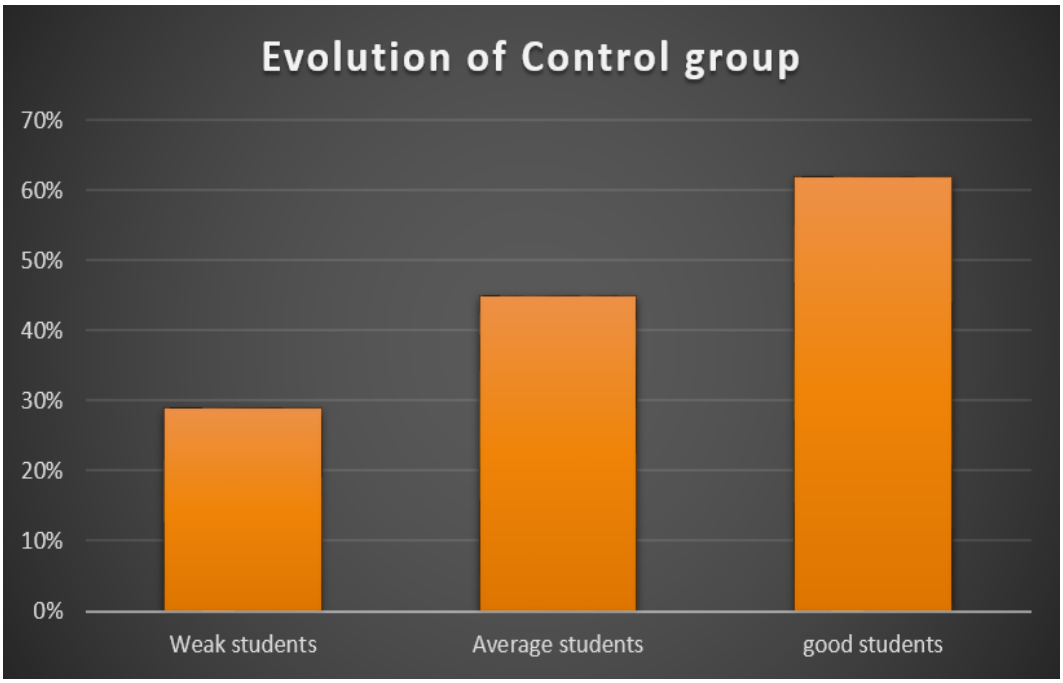


Figure 1.9: The Effect Sizes Calculated for the Control Group

Various experiments have been conducted to measure immersion. In [39] an experiment in which virtual reality was used along with the FMRI (Functional magnetic resonance imaging) technique. In this experiment three systems (Presentation system, Data acquisitions system, and Data analysis system) were used together to help measure the effect of virtual reality on the states of the mind.

Using this framework they performed an FMRI-VR experiment to measure the states of the player's brain while playing a 3D virtual reality game. The experiment was held on four subjects aged between 23 and 31. They played a first person shooter game navigating in a 3D virtual city map. The avatar that represented the virtual character in the virtual environment was controlled by pressing four MRI-compliant buttons inside the scanner: move

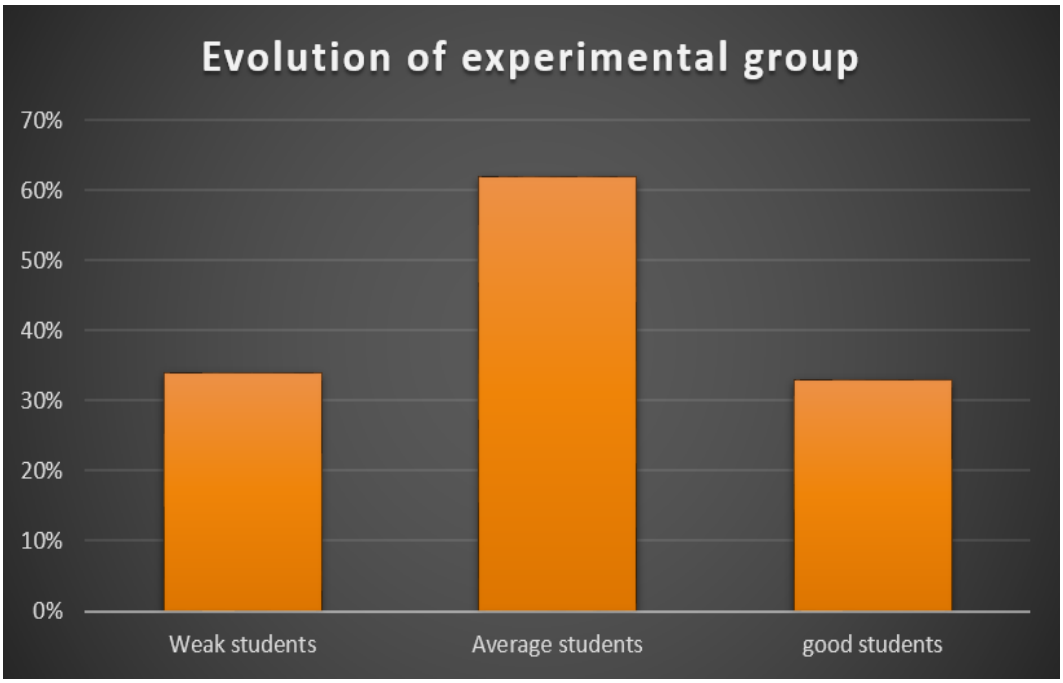


Figure 1.10: The effect sizes calculated for the experimental group

forward, move left, move right, and move backward. The researchers listed the brain parts that was activated as a result of the FMRI-VR experiment measurements. The results of the experiment supported the fact that the subjects who experienced the game confirmed the feeling of motivation and attention while using the virtual environment paradigm which is been confirmed also as being an immersive and highly realistic tool.

Another experiment for using the FMRI while playing violent video games has been done in [40]. The goal of this experiment is to investigate the neural activities of the behavior that presented during playing first personal shooter game.

The experiment was performed on thirteen German volunteers aged between 18 and 26 years who played first person shooter game for 5 hours a week. While playing the game, brain activity was obtained by means of fMRI within 12 minutes. The researchers rated how and to what extent the subjects interacted violently within specific virtual game environments while passing through five phases. First, passive/dead phase where no violent interactions occurred. Second phase is preparation/search when the player explored the environment without any opponent in the player's field of view. Third, the potential danger phase where there are some opponents appearing in the field of view and there are violent interactions expected. Fourth,

the under attack phase, where the player is attacked by an opponent and there are some violent interactions happening. The last phase is the active fighting where the player uses his weapons intensively and many violent interactions are happening.

The researchers compared brain activity of the player while facing violent interactions (third, fourth, and fifth phases) and when no violent interactions happening. Then, they described the brain areas that were significantly influenced by the five different game phases. The results showed there was an activation detected in some areas of the brain while playing violence games.

The authors in [25] postulated that immersion in games occurs when it monopolizes the senses. They performed an experiment to show that using sound and visual effects in games can effect emotions and promote fear and anxiety.

Thirty four students, 26 years old on average, participated in an experiment in which they played a horror game (Gears of War 2007) for eleven hours a week. The goal of the experiment was to study the effect of three basic properties of sound which are volume, timing, and source on participant emotions. During the experiment, and for the volume test, the subjects heard one selected sound of wolf howl, gunfire, or wretch growl. Also, for the timing test, they heard one selected sound of thunder, boomer growl, or creaking door. For the source test, they heard one selected sound such as locust growl, glass shattering, or footsteps. Quantitative data using 7-point self report surveys and qualitative data were gathered and analyzed.

The results showed that: high volume, synchronized sound with the corresponding visual stimulus, and visibly sourced sound effects are more effective at creating fear, and low to medium volume, scary, eerie or mysterious acoustic sound effects are more effective at creating anxiety, with no difference between timed and untimed sound effects for anxiety.

The flow state is one of the game attributes that triggers immersion. While playing a game the flow state can be reached when the player's skill level is balanced with the game challenge level. It's reached if the skill and the challenge are at the same level without the

player being overwhelmed, feeling the anxiety or feeling bored [45].

In [4], a group of researchers provided empirical evidence for a flow model derived from Kiili's flow model in game-based learning [45]. The flow model assumes that the relationships between the flow components it contains lead to an experience of immersion state. They performed an experiment in which they tested their flow model to understand the relationship between flow, games, and learning. They used an established immune system training game to examine part of the model on a group of students. The experiment was performed on 77 undergraduate volunteers, with age between 18 and 27 years old. They engaged in game play across multiple rounds while the flow state, play experience, and emotional experience variables were collected in parallel. The participants played the InnerCell game which is used to investigate the different game attributes on learning such as control, self-efficacy, story, real world, etc. To be able to measure flow, additional attributes were added to the game, such as feedback in the form of combat animation.

Before the players start experiencing the game, they completed a computer playfulness scale and a video game self-efficiency scale. After they played the game they answered the play experience scale, flow state scale and an intrinsic motivation scale. Scales ranged from strongly disagree to strongly agree.

After the audience responding to the scale questionnaires, the correlations, means and standard deviations were calculated from the experiment data.the analysis showed that in some rounds play, performance and emotions lead to a variance in flow state. In other rounds, they discovered that flow experiences affected emotional experiences and performance [4]. It also confirmed that the flow model has an impact on the learning process and contributes to immersion states when it's components interacts with each others.

This empirical validation was derived by using an off-the-shelves game that only provides some of the flow components needed to test their relationships. Generally, most of the research on flow studies tries to include more flow components in their own game implementations in order to address the limitations of off-the-shelves games. Moreover, there are

several factors and elements contributing to immersion and the cited research focuses only on the flow factor.

In the field of games, the flow experience maps well against the immersion process that the players experience while playing [41]. Flow describes a state of complete absorption or engagement in an activity and refers to the optimal experience [35].

1.2.3 Players and Games Features

Players play a main role in the process of effective learning via educational games. Some of the experimental studies examined the way players respond to game attributes and features and clarified the relationship between players and gameplay that could drive immersion element in the game which accordingly fosters effective learning [42], [46], [47], [48]. There are different kind of immersions that games offer and each one of them require different game attributes and player features to be exposed [49]. Sensory immersion element depends on the emotional experience the player shows while playing a game where the sounds and the graphics are balanced and constructed in a way affects his feelings and fosters his emotions ([50], [25]). When the game environment is real enough and constructed with a story that clarifies the goal of the game to the player, the player becomes absorbed in the word and will have a sense of personal control which will make him identifies with the game character. And all of that contributes to the imaginative immersion ([51], [49], [42],[52], [53], [54], [55],[56]). In his gaming model [42], Kiili discusses how players respond to game challenges and game objectives in a way that affects their perception of the learning content. When the challenges balanced with the player skills in the game, the player can fit the flow state which causes the challenge-based immersion. As discussed previously, there are some other attributes mentioned by ([35], [42],[52], [57], [58], [59], [60]) proved to be causers of challenge-based immersion which are: clear goals, game feedback, self-efficiency, intrinsic motivation and playfulness.

Games features and players features are discussed in details in the next sections.

1.3 Problem Definition

An important factor that GBL addresses is the lack of motivation for learning in traditional settings. A study found [28] out that 70% of high school students left school because they were not interested or motivated to continue their education. Moreover, a pan-European survey of five hundreds teachers showed that motivation was increased when computer games were included into the educational process [28].

Moreover, despite a large body of literature supporting the positive impacts of GBL on learning, others see that GBL research has been based on claims that cannot be substantiated [18].The authors in [18] state that games are no more motivating than instructional methods used in the control group. A reason, as the authors stated, is attributed to the fact that game content and game mechanics are not integrated in the games they analyzed. In 30 of the 31 pairwise comparisons in the meta-analysis, motivation was measured with a survey or questionnaire conducted after game play. There was no actual implementation of game based learning and no quantitative data to support GBL claims were provided.

The disagreement stems from the lack of balanced integration of concepts from pedagogy, instruction, technology, and content into an operational software model. Without this balance, GBL development becomes ad-hoc, and the resulting product will not meet the expectations of game makers, students and educators [61].

Clear goals and immediate feedback help players change the game play in order to improve their performance and reach the goal of the game. In each game scaffolding is provided which can be achieved by providing some levels to challenge the player and contract his knowledge gradually that helps in discovery learning. The discovery process allows the player to move in paths in a way that helps him to learn a set of knowledge or skill. This way of learning called a “learning progression". Moving from level to another one gradually and experiencing the learning progression forces the player master some of the prerequisite concepts and skills before learning new other skills. The player has the right to be provided with a curricular choice and a control over their learning. This can be provided by adding a "level

of agency" to the educational game. "level of agency" means that the learner has the ability to interact with the materials and feelings of belongingness and socio-emotional support in the situation. It allows the players to create their own hypothesis and experience in order to solve a problem. Also, students as players prefer rich graphics and tasks that are fast, active and exploratory and they are more engaged when the game is narrative supported by moving graphics.

Our approach stresses independent learning supported by technology; however, it is a departure from educational technology. Unlike educational IT that constrains learners into rigid structures and prescribes their knowledge acquisition tasks, our approach seeks to establish a model that triggers and encourages the natural and instinctive urges of the child to explore lively and exciting "knowledge worlds" and to construct subconsciously their own knowledge as they wish, without any guidance or intervention. The child will feel as if in a toy store free to play with any toy and jump from one toy to another. Thus, the learner is freed from any constraint. He/she is immersed in a context wherein he/she finds himself/herself in a state of flow, eagerly engaged in activities that promote learning. The basic idea is to immerse learners in authentic and familiar virtual worlds and allow them to freely explore these contextually rich environments. Through interactivity, the exploration process engages them into activities that enrich their cognitive structures by promoting active and meaningful learning. Rather than being just a spectator, the learner is an active agent impacting and being impacted by the environment constituents, which are themselves self-aware dynamic agents. Exploration embeds a strategic scheme to personalize one's knowledge construction path. The learner's universe is modeled as a micro-world that is a tiny world in which a student can explore alternatives, test hypotheses, and discover facts that are true about that world [62].

Overlaying this conceptual map is a scene that starts with the universe and zooms in on the smaller components of the child's world, such as home, toys, parents, schools, and other interesting elements surrounding the child. The structure of the scene transparently captures linguistic, visual, and relational information about a given theme. Dynamically exploring

moving scenes immerses the children in their environment and allows them to construct their own story.

Our main objective is to support effective learning by immersing the player in a game world. Our overarching goal is to provide children with immersive game-based learning environments to support Arabic linguistic skills acquisition. Various studies have shown that virtual immersion leads to greater engagement, which, in turn, leads to effective learning. Thus, our Educational Virtual Environment (EVE), built on cognitive immersion principles, immerses players (learners) into a magical, yet authentic, world wherein they can explore various concept-rich ecosystems. The exploration journey becomes a unique self-constructed adventure requiring the use of physical and cognitive skills. Currently, EVE consists of a 3D game on a smart phone mounted on cardboard virtual reality glasses and a wireless controller. This configuration allows the player to play the game while learning Arabic by exploring various environments and facing physical and cognitive challenges to move from one level to another.

Consequently, we postulate that immersion increases learning. To demonstrate this hypothesis we will design experiments to measure the significance of the effect size.

Also, the literature we reviewed suggests that the most important factor which contributes to immersion while using virtual reality is the feel of presence (e.g. [63]). However, none of the papers discussed the factor of presence along with the three keys (imaginative, emotional, and challenge-based) of the immersion that are available in the normal immersive games that do not implements VR environments. Consequently, we seek to develop a model which implements the three key contributors to immersion along with the presence key element.

The model we want to examine is synthesized from an already existing models (e.g the flow model) we investigated in our review of the literature. The existing model is built upon the flow model used in [4], and the gameplay experience model (CSI model) examined in [44]. The new model will add the presence-based immersion key factors that contribute to

immersion while using the virtual reality technique in games.

The next step after developing the model that has all the attributes which contribute to immersion, we will implement all the attributes in a 3D game that supports the virtual reality technique. Then we will test the model by having an experiment by which we will let the audience experience the 3D game and analyze the resulted data to see if the model attributes implemented in the game contribute to immersion, allow the player to be engaged and motivated and have an impact on the learning process or not.

1.4 Research Objectives

The main objective of this research is to develop a framework to support our hypothesis: that immersion contributes effectively to learning. Also, we aim to develop a GBL model to engage and immerse children in a virtual educational environment to enhance the acquisition of Arabic linguistic skills. We will build a model and its implementation and will conduct experiments to assess this hypothesis by performing the following tasks:

- Assess the state-of-the-art in game-based-learning and immersive educational games.
- Investigate learning practices in grade one.
- Develop a model which integrates learning and playing and supports virtual reality features.
- Implement a prototype to demonstrate the feasibility of the model.
- Evaluate the effectiveness of this model through experiments.

1.5 Outline of this Thesis

In what follows, we present an introduction to the immersive game-based learning (GBL) and the motivations that shows the reasons behind its adoption. To have a clear understanding of the immersive game based learning and how it is affecting the learning process, we searched many implemented models and prototypes and summarized their results. After

the searching process, we decided to build a framework that integrates the virtual immersive worlds with the educational game we are building. To demonstrate the feasibility of our goal, we implemented an immersive educational game using game technology. This thesis is structured in the following approach:

In chapter 2, We introduce a proposed immersive software model. The proposed model is a combination of some immersion frameworks that have been found in the literature. We gather all immersion attributes contained in the frameworks we found and we include them in the proposed model, so it can promote immersion. Also, we include the most important factor that contributes to immersion in our proposed model which was missing in all of the frameworks we found. Then, we map the proposed model to a 3-Dimensional game we built to enable the immersion feature inside its environments.

In chapter 3, we develop a model to build a game-based learning prototype by performing some phases. First, we review the educational system in the United Arab Emirates in some detail. Then we explain our approach to modeling GBL for linguistic skills acquisition and recommend solutions to the major challenges we noted in the educational system. We identify game-based learning components. Then, we identify the idea and the goal of the model. We describe the main components of our model and explain each in detail. We also describe the structure of the game. In addition, a description of our prototype implementation is described.

In chapter 4, We evaluate our model by conducting three experiments, to assess our the effectiveness of the proposed models, and conclude the findings.

In chapter 5, we summarize this thesis.

Chapter 2: Proposed Software Model

2.1 Immersion in Virtual Environments

In this chapter, we will review the concept of immersion and its dimensions, as well as an illustrative model supporting immersion. Subsequently, we will elaborate a model that integrates features to enhance gameplay and promote immersion, the feel of presence and engagements within GBL environments.

Our discussion of immersion is within the context of virtual environments associated with games. Thus, immersion concerns the state of mind of players, who, through their interactions with the game, "live" a variety of experiences. The intent of immersion is to deepen and enrich these experiences. To facilitate the presentation, we first describe the structure of virtual environments, and then elaborate on some dimensions of immersion.

2.2 Immersion Dimensions

There are several perspectives on the dimensions of immersions [64]. We limit our discussion to the three dimensions of immersion introduced in the SCI-model (sensory, challenge-based, and imaginative model) and illustrated in Figure 2.1 [49]. This model relates immersion, gameplay experience, game characteristics and player traits.

2.3 Sensory Immersion

Sensory immersion is represented by audiovisual attributes of the game and can be achieved by the 3D worlds which surround the players comprehensively. The head mounted display (HMD) and the evocative sounds vividly capture the real world and act as powerful triggers leading the player to become engaged in the game world [50].

As shown in the SCI-model, sensory immersion is affected by the audiovisuality of the game that is reflected in the interface features. In [**?**] the researchers showed that visual and auditory sources affect player's emotions. They performed an experiment in which the

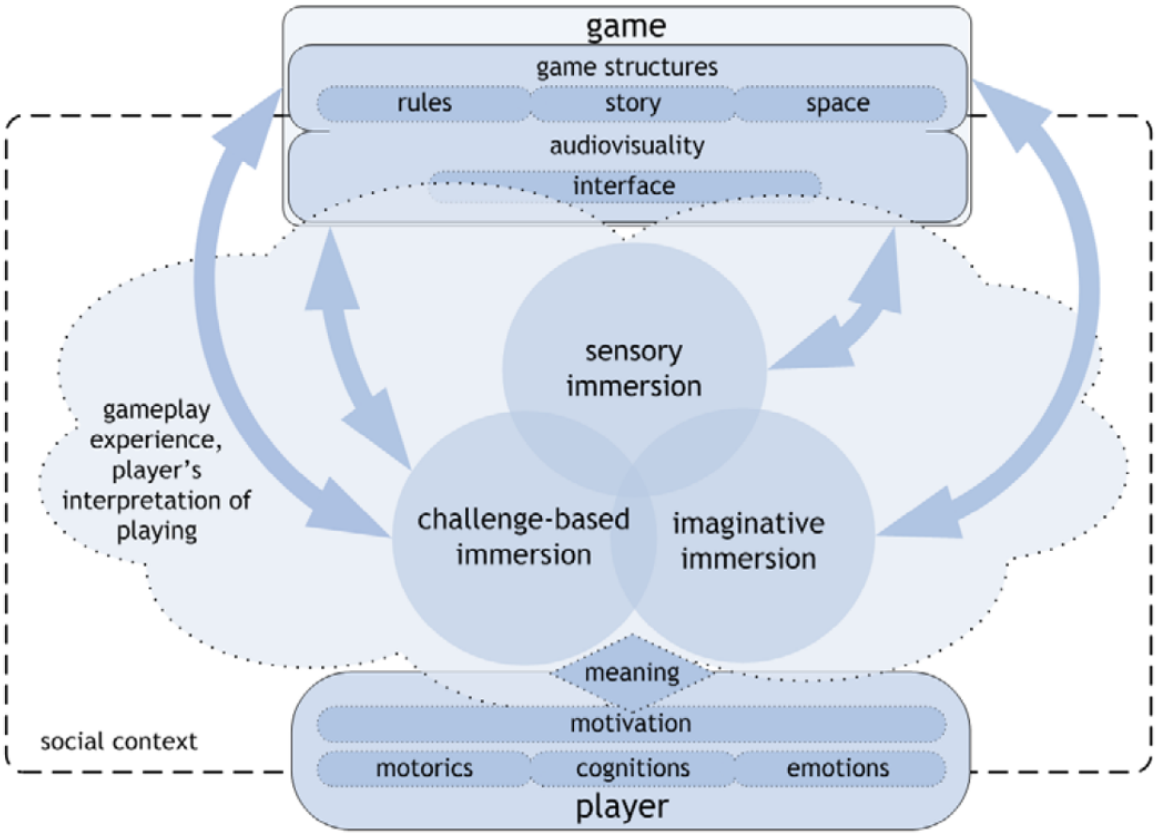


Figure 2.1: SCI Gameplay Experience Model

players play 3D games and observed their reactions and emotional states. The results showed that timed high volume sound effects with visual gameplay elements, e.g., the in-game enemy, cause the feeling of fear among players. Also, they found that low to medium sound effects with invisible visual gameplay elements induce a state of anxiety.

The researchers in [65] showed in their experiment that emotional states are affected by the player's personality traits such as self-esteem and extraversion. For example, players with a high level of self-esteem will feel guilt when making mistakes in the game and not asking for help. Those with a low level of self-esteem will be ashamed if someone comes to help them when they face a problem (e.g., they cannot overcome a challenge) while playing. Also, the researchers showed that the player's emotional states affect the visible bodily expressions, like voice intonation and facial expressions, as well as the invisible expressions such as blood pressures, heart rate, skin conductance, and temperature.

These research efforts identified some of the player traits and game features that can

contribute to the emotional experience of the player. The player traits are bodily expressions (e.g., eye directions and head movement), emotional states (e.g., feeling of anxiety or boredom), and personality traits (e.g., self-esteem and confidence). Game features are sound presence and graphics presence. We will discuss later the various attributes associated with sound and graphics.

As discussed in section 1, the experiment performed in [**?**] showed that visual and auditory game features create immersion and evoke emotions.

The diagram shown in 2.2 represents a model we synthesized from the literature. It illustrates the interaction between player traits and game features that create the emotional experience which contributes to sensory immersion.

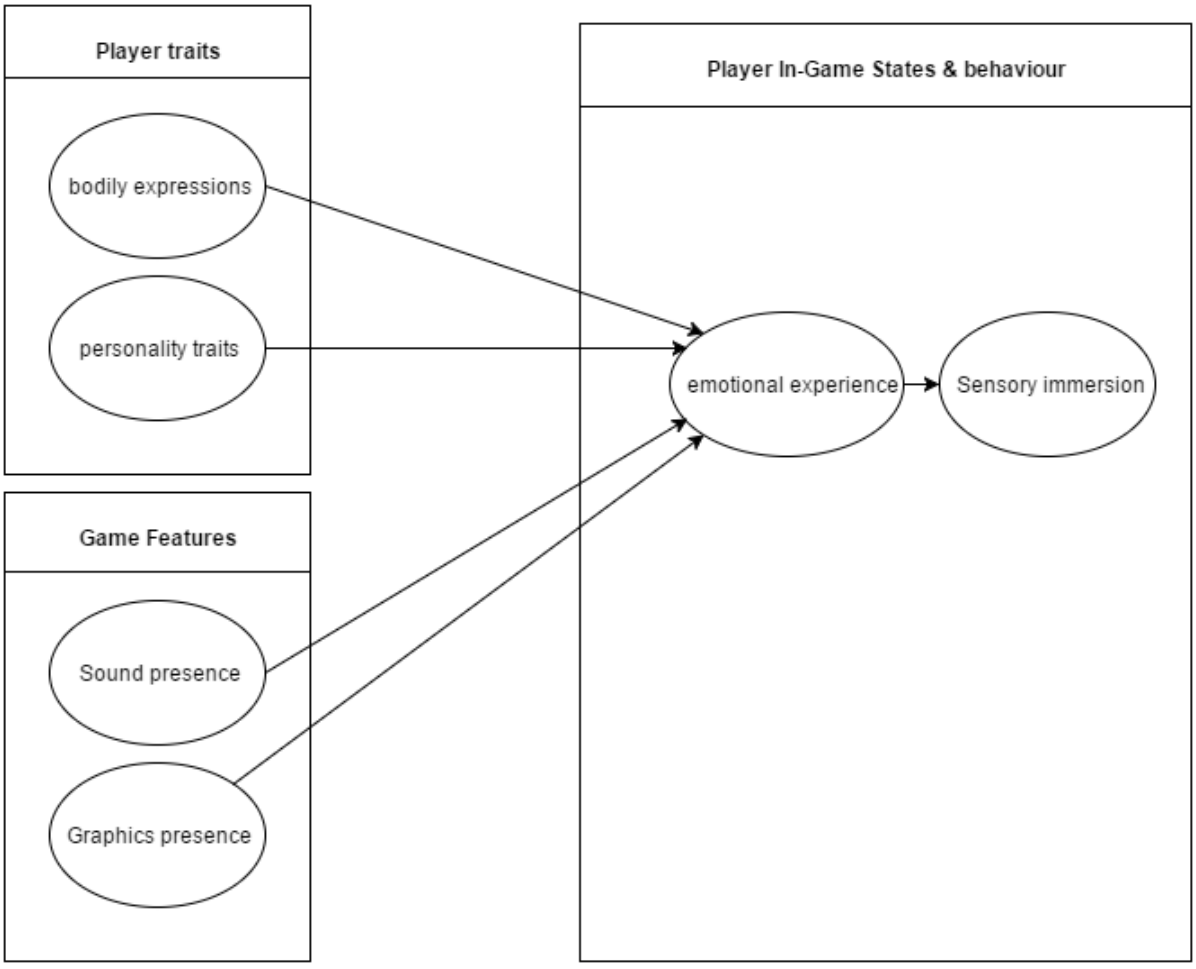


Figure 2.2: Sensory Immersion Model

2.4 Imaginative Immersion

Results of an experiment reported in [49] show that imagination has a higher impact on problem solving [51]. Imaginative immersion can result from a game that has three characteristics, as presented in the SCI-model, story, control, and world environment. In an experiment using Kiilli's flow model [45], participants stated that when they played a narrative game supported with a story, the goal of the game becomes clear. Based on Kiili's model, a clear goal contributes to a flow state which is one of the factors that induces immersion states while playing ([42],[52]). The world environment construction and its components affect the way the player perceives this world. In an experimental study, a virtual PILE system was used to teach the English language for second grade students. PILE is a video-capture virtual reality technology that capturers the students' physical movements while interacting with the elements of the virtual environment presented to them. The experiment was divided into an experimental group consisting of 30 students using the PILE system, and control group consisting of 30 students who were instructed using PowerPoint slides. To test their initial English abilities, the students were given a pretest that included five items which are related to the English second grade curriculum. After performing the experiment, they were given two questionnaires, the first one was an eight-item learning motivation questionnaire and the second one was a short feedback questionnaire to measure the participants' feeling of enjoyment, sense of being in the environment, control, perception of the environment for being realistic, feedback, perception of difficulty while performing the task, and level of control during the experience. The results showed high scores in all the measurements and the students feedback was that they experienced the learning environment in a way felt like reality. Also, they confirmed that they were highly immersed in the virtual educational environment [53]. Based on other experimental studies ([53],[54], [55],[56]) the researchers proved that using realistic virtual worlds for educational purposes assesses the better understanding of the concepts learned and virtual reality has the ability to illustrate concepts that could not be seen otherwise. Also, the participants a feedback that they did not want to leave the virtual system and they were totally absorbed in the world feeling a sense of presence.

The control over actions is the ease of movement of the player in any direction and being able to move in the places he has the freedom to choose by himself [52]. The researchers in ([66], [67], [68]) stated that control over actions happens when the player is able to move his avatar and feels control over input devices (e.g. the player can move in all directions freely under his control). In [53], the ease of control was another aspect to be measured while experimenting the educational game on students. The students agreed that controlling the user interface with their own physical movements was intuitive.

The feel of presence and the control over actions features help the player to identify with the game character which was shown to be one of the factors that contribute to imaginative immersion [49]. In Figure 2.3 we synthesize an imaginative immersion model which captures the interactions among player traits and game features we discussed in this section.

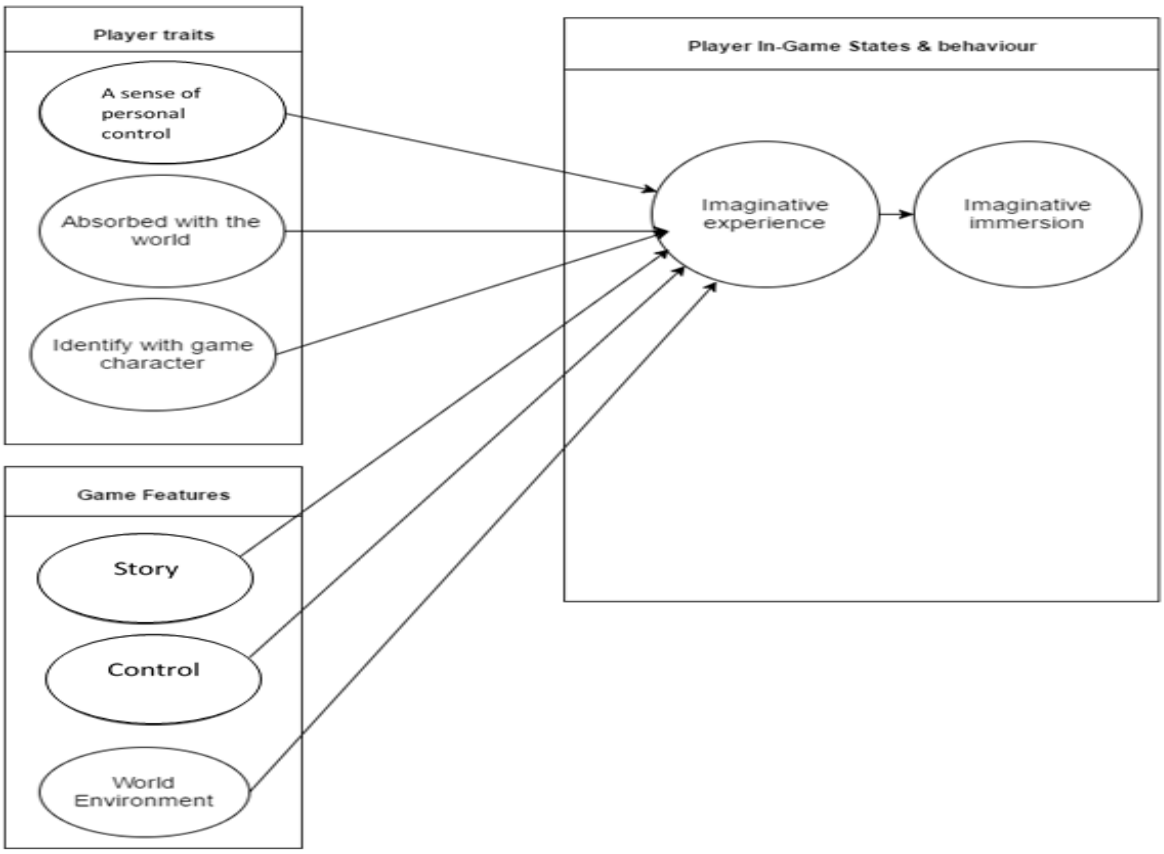


Figure 2.3: Imaginative Immersion Model

2.5 Challenge-Based Immersion

The third kind of immersion is the challenge-based immersion as described in the SCI-model. Flow is an important factor that contributes to the challenge-based immersion as illustrated by ([35],[42],[52]). Flow is an experience that results in heightened motivation, intense engagement, and receptiveness to information [35]. Csikszentmihalyi identified some factors that trigger flow: 1) challenge-skill balance 2) intrinsic motivation, 3) ability to concentrate on the task (self- efficiency), 4) clear task goals, 5)immediate feedback, 6)sense of control over actions, and 7) playfulness [35].

2.5.1 Challenge Skill Balance

Challenges “are situations that need great mental or physical effort in order to be done successfully and therefore tests a person’s ability". The difficulty of the game is defined by the interaction between challenges and the player facing them. These challenges must at an appropriate level of difficulty without overwhelming the player [52]. If the player skills level is lower than the challenge level, anxiety will ensue. If the player skills level exceeds the challenge level, boredom results. And if the skill and the challenge are at the same level without the player being overwhelmed, the flow state will be reached ([69], [42],[52]). Figure 2.4 illustrates the flow state the player reaches when the skills match game challenges.

In [70], the kind of challenges that induce the player to continue playing without the feel of boredom are explained. These are:

- Timing and Rhythm: Where the player is challenged to press the right button at the right time.
- Spatial awareness challenges:
  - The perception of the game world and the navigation in the adventure world become easier when the game elements and objects look familiar to the player.
  - Showing the player the directions and his location by providing a map in order to

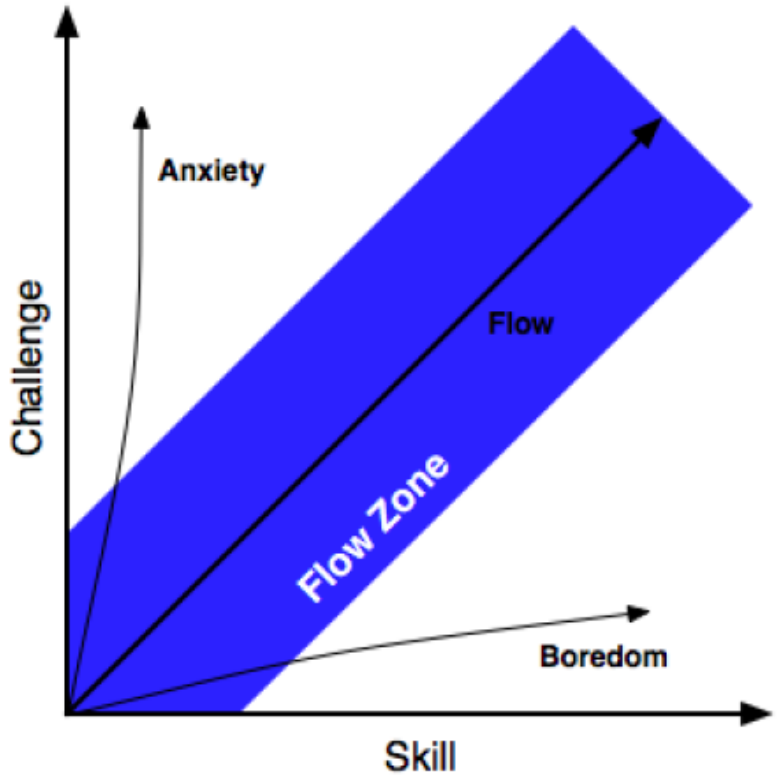


Figure 2.4: Skill-Challenge Relationship

make this challenge easier.

- Showing the player the directions and his location by providing a map in order to make this challenge easier.
- Looked Doors:
  - The existence of an obstacle that prevents the player from proceeding ahead through the game, e.g., to go to the next level, he has to find the keys to open the cages and free all the animals of the current level.
- Traps:
  - An object that harms the player to prevent him from going in a given path or repeating that move again. It is fun for the player to find traps without being caught.

2.5.2 Feedback

Malone defined feedback as a game element that gives the player a knowledge about their performance in the game [57]. Also, feedback lets players be aware of their success or failure and the outcome of their actions. According to Csikszentmihalyi's original experimental-based definition of flow, feedback should affect the player in a way that allows him to be in the flow state [35].

2.5.3 Clear Goals and Control

Csikszentmihalyi showed in his research that clear goals and control contribute to the flow state [35], and as discussed in the imaginative immersion section clear goals and control cause immersion to happen [52]. Immersion is one of the results of flow [35].

2.5.4 Intrinsic Motivation

As Csikszentmihalyi stated that when someone is motivated to continue working on a task just for the sake of it, the task is called an autotelic task. Intrinsic motivation is derived from the satisfaction with a specific task and is the drive to perform that is born from the task itself ([72], [73]). The autotelic task that drives the intrinsic motivation requires exploration and information processing [74]. Based on a study performed to examine the impact of motivation on students, it was found that students who were intrinsically motivated performed better and were more engaged in their tasks [59].

2.5.5 Self-efficacy

Self-efficacy happens when someone believes in his ability of being successful to be engaged in an event or to complete a task [59]. One of the core elements of the flow state is the ability to concentrate and focus on a task [35]. In addition, flow state works as a channel between the video game self-efficiency and learning [71].

2.5.6 Playfulness

An individual's disposition towards engaging in play is termed playfulness [60]. The researchers in [52] showed that playfulness is positively related to an individual experiencing play behavior. When the player shows the willingness to play, the experience will be similar to the experience of flow state's autotelic experience, as play is intrinsically rewarding ([72], [35]). Hence, players who are willing to play and show that they are interested in playing a game, will experience play and will reach flow accordingly.

Figure 2.5 shows the flow model which was evaluated in [52]. The model contains the player traits and the game features that when they interact they contribute to challenge-based immersion. The results of the evaluation process showed that when the elements in the flow model interact they cause the flow state to happen. Moreover, they confirmed that immersion, motivation, intense engagement, receptiveness to information, merging of action and awareness, loss of concern for the self, and altered sense of time are the effects that the subjects experienced while playing ([35], [42],[52]).

Feedback is provided to the player to acknowledge him about his progress and performance. As the player makes progress exploring the different environments freely, he will be experiencing intrinsic motivation because he will continue playing for the sake of exploring the environment and surviving the challenges. Playfulness and self-efficiency are player traits and they depend on how the player perceives the game. If the children (as a player) has the willingness to play the game and knows exactly that he has the ability to complete the game task, he will be experiencing the play behavior which be similar to the flow state's autotelic experience.

2.6 Presence-based Immersion

The three kinds of immersion discussed in the previous section were shown to be found in all kinds of 3D games that virtualize real worlds and integrate the components of the immersion-related models that we discussed earlier [49].

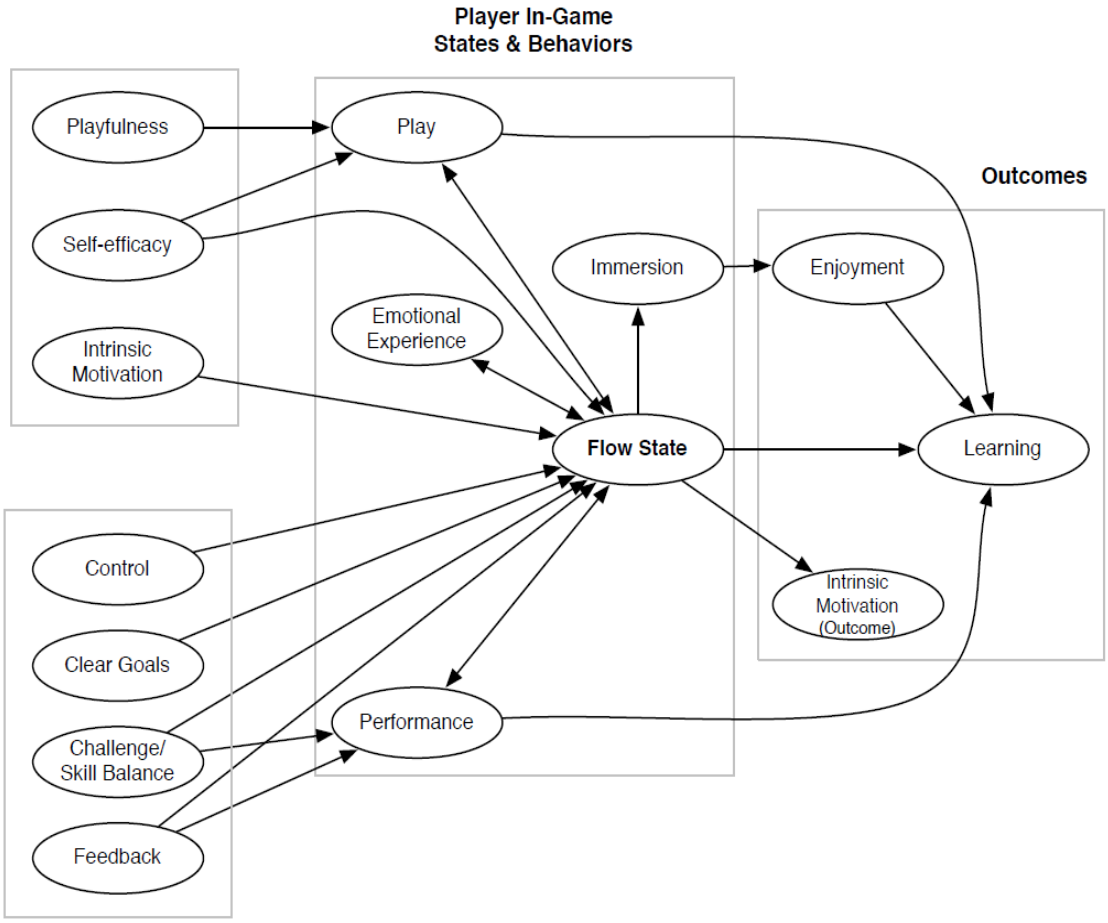


Figure 2.5: Challenge-based Immersion Model

The feel of presence is another feature that adds value to the immersion element induced by virtual systems [50]. An experiment was performed in [73], they found that reported presence was higher for the HMD (Head Mounted Display) modes, where the virtual environment was used, and lower for the screen based mode. Researchers in [74] experimented the relationship between emotions and immersion with the feel of presence. The results suggested reported some factors that contribute to presence which are: Player traits, emotional experience, special presence, engagement, world realness, and emotional environment. Multiple studies [75], [76], [77], [78], [79], [80], agree on the fact that special presence is caused by some media characteristics consisting of media content and media form. The media form contains present sensory information and the degree of control over actions the user can have. The media content contains actors, events, and objects present in the system environment.

As we discussed in the previous immersion models, sensory information triggers emotional experience, and emotional environments foster the feel of presence [74]. Also, there is agreement among researchers [53], [54], [55], [56] that the semi-real worlds in their content can cause the feel of presence. Control over actions, a component of the flow model, was shown to be one of the factors that causes the flow state to happen. Hence, engagement is guaranteed as an outcome when the player experiences the flow state [52]. As a result the feel of presence is a consequence of the engagement process [74].

Figure 2.6 shows the presence-based model which contains the elements that cause the feel of presence while using virtual worlds. Elements of this model will be implemented in our 3D game the same way discussed previously in the previous immersion models which share the same contents.

Intense engagement, receptiveness to information, merging of action and awareness, loss of concern for the self, and altered sense of time are outcomes resulting from these immersion models [52] , [35]. In our research [81], we observed the effect of engagement and motivation of educational games on the players (as learners) who perform some of the cognitive activities (e.g. perceiving, associating, recognition., etc.) while playing. The results showed that the students who played the educational game performed better than those who experienced the traditional ways of learning. Figure 2.7 shows a complete model which is a synthesis of the model we discussed. It illustrates how various factors contribute to immersion. Consequently, integrating immersion and learning which enhances engagement of players when they carry out learning activities, which in turn, affect positively the learning process.

The model we proposed is a presentation of key game attributes that contribute to immersion. The game attributes are classified into four main immersion dimensions: the sensory, the imaginative, challenge-based and presence-based immersion. The sensory immersion simulates the audiovisual attributes of game. The sounds and real-looking graphics can contribute to immersion as stated in the literature. The challenge-based immersion is another dimension that is achieved when the game challenges are balanced with the player skills and capabilities.

Figure 2.6: Presence-Based Immersion Model

Challenges included in the game varied between the logical and the strategic and when they are balanced with the player capabilities the flow state is achieved. The flow state is an indicator that the players are focused on their goal while playing until they complete the mission, and they handle the full control in the game. The imaginative immersion happens when the player is absorbed in the story and the game environment. When the player is experiencing the flow state mode, emotionally triggered by the audiovisual manipulation, having a full control

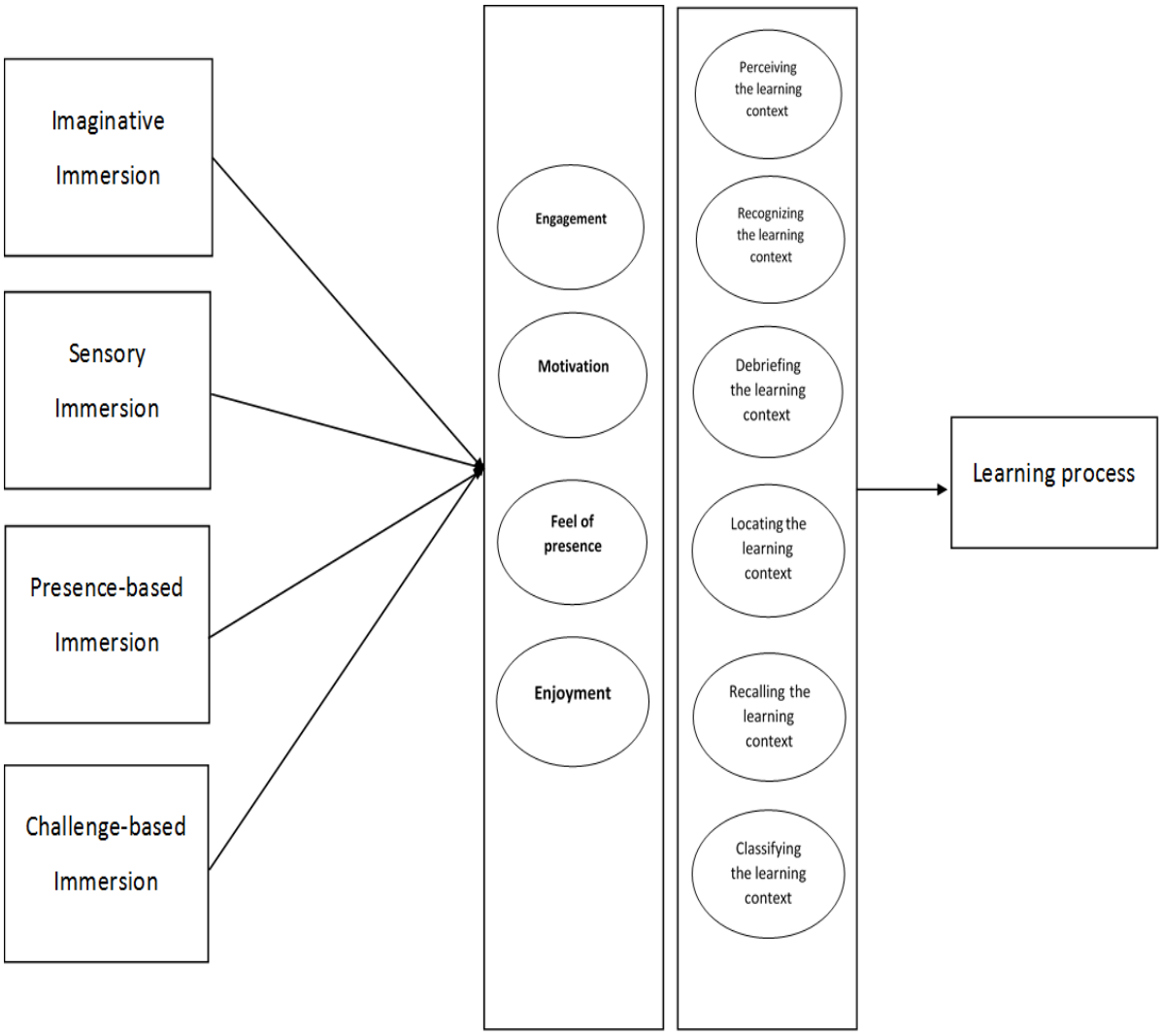


Figure 2.7: Proposed Immersion Model

in the game play and identify with the game character he becomes engaged and he feels the presence in the game. All of that contributes to the presence-based immersion.

When the immersion outcomes (e.g. engagement and enjoyment) integrate with the learning activities the player perform while playing the educational game, the learning process happens and becomes more effective.

2.7 Mapping the Proposed Model to Our 3D Game

We mapped the researchers' findings related to sensory immersion into our 3D game gameplay. For example, as a component of our game world, the farm environment (as discussed in section 3.2.3) has rats that act as enemies that the player must avoid. The rat images

are visible to the player and a concurrently a high volume sound of the rat plays in order to trigger the feel of fear in players. Also, players can hear a low voice with no graphical source available when they enter the area of each animal, which let them end up questioning and wondering: where is that voice coming from?

Also we implemented the features of the imaginative immersion model in our 3D game. We created a real environment, as shown in Figure 2.8, that illustrates the concepts in a way that the player can feel the sense of presence and allows him to be absorbed in the game. Also, the game started with a story science to clarify the goal so they can be in the game flow. The inputs are manipulated in such way that the player familiar with, so they can move in the environment easily, e.g. the player uses the right key to move to the right direction. In addition, the player has the freedom to choose among the environment he wants to investigate among four different environments and the freedom to choose the animal he wants to play with in each environment.

Figure 2.8: Illustration of the 3D Game World

The challenges in the game are implemented in a way that suits the players' skills level. As our target users are kindergarten students, the challenges that will be implemented are as follows:

- Timing and Rhythm:

  The children will be challenged to press the right button at the right time to be able to avoid enemies and obstacles and to destroy the cage to free the animal before the key disappears.

- Spatial awareness challenges:

  - As we confirmed before the world is constructed to be realistic in a way that contains real looking graphics, objects and elements. Also, the physical simulations of the objects are implemented in a way that mimics the real world simulations which makes them look familiar to the player.

  - A map that shows the player the directions is provided in the game to make this challenge easier.

  - Looked Doors:

    * For the player to be able to proceed to the next level, he has to find the keys to open the cages and free all the animals of the the current level.

  - Traps:

    * Some of the tools that warn the player from repeating some movements again are placed in the environment.

Chapter 3: Modeling Immersive GBL for Effective Linguistic Skills Acquisition

3.1 Introduction

Language is a a set of well-defined rules and clauses [1] that when children master it they will be able to use and understand simple and complex words, sentences, and ideas [1]. Research studies show the effectiveness of multimedia in supporting learning outcomes, and games are instances of resources that provide multimedia to players([24]). Further research emphasize GBL positive effects on learning [82], demonstrating that games provide platforms for players to acquire new skills [83].

In this chapter, we overview the United Arab Emirates curriculum requirements related to our goal and propose virtual environments that embed these requirements. These environments will serve as backbone for our game. Subsequently, we elaborate the components of the model that forms the basis for the implementation of our game-based learning system. The model incorporates the immersion principles, the immersion model, the game characteristics, presented in the previous chapters, and the curriculum requirements.

3.2 The United Arab Emirates Curriculum

Reading skills are a fundamental requirement for acquiring the different facets of knowledge. There are various resources to help the students master this skill; one of them is to know the different sounds of the alphabets and to know the expressions that are related to the linguistic methods. Reading also is a linguistic skill that is meant to translate linguistic symbols to pronounced sounds and acquired by intensive training so it becomes a daily routine that is not separated from the reader daily lifestyle. In addition, it becomes a basic tool to acquire other linguistic skills such as writing and conversation. Figure 3.1 shows the three facets of reading the curriculum emphasizes.

Besides its focus on the reading facets and reading stages, the curriculum addresses strategies to support students in acquiring and mastering reading skills. Reading skills and

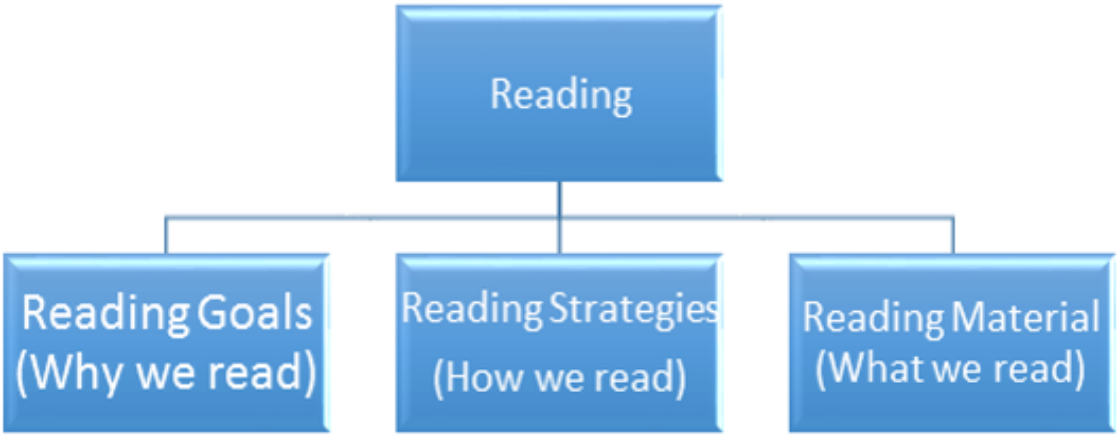


Figure 3.1: UAE Curriculum Reading Facets

stages proposed by the curriculum are as follows:

- Pre-reading stage: in this stage the reading material is chosen, self-preparing and preparing for the expression reading and the pronunciation.
- Reading stage: in which the written symbols and alphabets are translated to meaningful sounds and structures. Also, it is related to the fluency and the clear sound, and the ability to sell the feelings and the thoughts to the reader.
- Analysis of the reading materials: which means understanding, analysis of ideas, meanings and events, analysis of the paragraphs structures, connection between meanings and constructing new meanings and ideas.
- Evaluation of the reading material.

Strategies to support the students reading skills proposed by the curriculum are:

- Empowering students to master the reading tools.
- Training students daily on the reading process.
- Training them how to avoid the challenges that confront them while reading.
- Helping weaker students to be able to read.
- Encouraging them to read so they can be able to choose the reading material.

- Making time for free reading to make the reading process interesting.
- Raising their confidence in their reading ability
- Discussing reading materials with the students.

3.2.1 Curriculum Requirements

- Reading outcomes
    1. Pronounces correctly the letters of the alphabet.
    2. Distinguishes between the letters that have the same sound.
    3. Describes the characters used in the environment.
    4. Recognizes the story elements and describes them
    5. Be able to organize the story events.
    6. Reads the alphabet of one word fluently.
    7. Remembers important points in a story.
    8. Analyzes story events, actions, and interactions.
    9. Relates elements and be able to understand them.
    10. Answers questions related to the learned material and concepts.
    11. Understands common concepts, and discusses them.
- Objectives and goals
    1. Complement the book with various and supportive activities, in a way that allows the teacher to choose the activity which suits the student educational level.
    2. Help the teacher design the linguistic activity which is tied to the desired educational objective.
    3. Help students and empower them to master the required linguistic skills.

4. Consider the differences between individuals when performing the activities.

3.2.2 School Curriculum Content

Figures 3.3 and 3.2 show a sample of the learning content. In these samples the content is a narrative augmented with pictures of the animals.

Figure 3.2: Another UAE Curriculum Content Sample

الاسم:

الصف: الشعبة:

المهارة: القراءة.
المستوى: مبتدئ

الناتج: يحدد عناصر القصة، ويصفها.

أقرأ القصة، ثم أجيب عن الأسئلة:

الأرنب الوبيء

انطلق الأرنب والسلحفاة يجريان بسرعة، فقد أعلن الحكم بدء السباق.

كان الأرنب يجري بسرعة كبيرة، فهو مشهور بالجري السريع أما السلحفاة فقد كانت تمشي بمشيتها البطيئة المعروفة.

بعد مدة من الزمن رأت السلحفاة خصمها الأرنب ساقطًا في حفرة، فرحت السلحفاة وقالت: أستطيع أن أسبقه الآن، وبذلك أحقق أكبر إنجاز رياضي لعالم السلاحف.

ابتعدت السلحفاة عن الأرنب، وهي تبذل كل جهدها للوصول إلى خط النهاية الذي صار قريبًا منها الآن، لكنها لم تواصل جريها، بل عادت إلى الأرنب، وهي تقول لنفسها: لابد من إنقاذ الأرنب، فقد يقع في قبضة صياد، أو ثعلب جائع.

أسرعت السلحفاة، ورمت للأرنب غصنًا يابسًا صار سلمًا للأرنب، فتسلقه بسرعة، ونجا، وانطلق الاثنان يجريان من جديد.

فاز الأرنب في السباق، لكن السلحفاة حصلت على الكأس، بعد أن قدمها الأرنب لها، وهو يحكي لمشاهدي السباق ماحدث له.

صفق الجميع للسلحفاة الشهمة كما صفقوا للأرنب الذي لم ينس الجميل.

الفرح في القراءة والتعبير، السنة الثالثة، دار السفير، ص132–133

Figure 3.3: UAE Curriculum Content Sample

The content of the Arabic curriculum learned in the primary school level is designed to achieve and meet the requirements and goals listed in this section. The linguistic concepts are presented in a narrative way altogether with related pictures.

Our analysis of the curriculum and the comparison with related work in the reviewed literature lead to the following observations: some of the animals pictures are presented in conceptually-unrelated environment, preventing children from associating a given animal with its habitat. There are no sounds associated with the animals and the learning contents, while sounds are important components of multimedia resources that help foster the learning pro-

cess [24]. Moreover, children are not given the ability to interact with the material. Studies shown that interaction is one of the important elements that supports effective learning [53]. Also, animals, belonging to different habitats (e.g., farm, forest, sea), are randomly presented together. This lack of conceptual togetherness in the presentation does not afford children the power to be able to recognize groups of animals that share the same habitat. Briefly, the presentation does promote the capacity to relate concepts with their corresponding pictures in order to facilitate retention and recognition.

Consequently, to better support the curriculum and its goals, we sought to address these shortcomings by developing alternatives to support knowledge acquisition in a different way. The following section illustrates the steps we carried out to achieve this goal.

3.2.3 Proposed Curriculum Content

To support the UAE curriculum, we built a new curriculum that our game follows. The new curriculum is an outcome of a search we did in four countries' curricula about the common effective ways of learning they follow. The four countries are Egypt,United kingdom,United states America and Japan. The new curriculum (as shown in Figure 3.4) suggests, the learner has to be exposed to a narrative learning atmosphere in environments that contain sounds, graphics, shapes, actions, and events to allow children to interact with the elements presented. To cover the learning content in an interactive context, we created different environments containing a variety of animals, such that their names cover all the required letters of the alphabet. Also, by presenting the different animal types that share the same environment, we allow the child to construct a higher level of knowledge by relating the animals to the environment they are living in and relating each animal to the other animals living with it in the same environment. Briefly, the building blocks of the learning content are presented in contexts that offer highly-related concepts.

Grade	*Listening*	*Reading*
KG1	- Introduce the letters sounds in simple common words and songs. ▫ Child can listen to each letter in the word individually. ▫ Child can listen to song that contains the intended letters and associate the song with pictures. - Relate the words with regular events and scenes in child life to make it easy to remember. ▫ By making objects or pictures that represent words and putting it in suitable environment. ▫ Child can play with objects Ex: put the object "تفاحة" in suitable environment and let the child do action "like collecting it from tree".	- Associate simple common words from child environment in the material presented to the child. ▫ Present sample and common "useful for children" words. ▫ Words is related and in one environment. ▫ Words contain same letters; so child can focus in these letters. - Introduce the letters and relate them to specific movement or shape to make it easy on the child to remember them. ▫ Child can play or interact with letters. ▫ Specify some movement for the letter when child do specific action. Ex: letter "أ" do movement like a dance when the child chooses it.
KG2	- Encourage the child to recognize different sounds of the letters in listening practices. ▫ Represent each litter in different position at different words. ▫ Child is able to choose which letter to hear. Helps child to understand that "مـ","م","حـ"..."بـ" Is the same in sound? ▫ Child is able to listen to the pronouncement of the word. - Practice the child to listen to different people and interact with them. ▫ Child can deal with many different objects or people ▫ Understand what the objects want through watching a story which contains pictures. ▫ The story is associated with sounds to make it understandable. ▫ Child listens to sounds from the people or objects.	- help the child to learn how to pronounce letters and read in clear way. ▫ Associate each letter with a sound; so child can know how it pronounces. ▫ Then give each word a sound of pronouncing it to let the child understands how the letter will be pronounced inside the word. - Encourage the child to read simple words and sentences. ▫ By listening first to word and sentence. ▫ Then let child communicate with object which ask him to try to read or to do something make him reads the word or the sentence. Ex: ask him to search for the picture that represent a word " ابحث عن صورة (سيارة)"
Grade 1	- Identify the sounds of letters in different cases. ▫ Listen to many words having the same intended letter but in different positions. Ex: represent letter "م" in many cases "موز" or "تمر" or "لحم". ▫ Put the intended letter in one sample sentence but in different cases. Ex: "ماجد رسم سمكة" - Information is provided by a speaker or presented through other media. ▫ Make the object in the game speak. ▫ Represent a story with a speaker. - Involve students in conversations with others by listen attentively; ask questions for clarification and understanding the topic. ▫ Let the child deal with the represented environment by Specify actions to each one of the objects. ▫ This action is related to what the child asks or performs.	- Students learn to read appropriately complex informational text. ▫ Child read sentence has three words or more. ▫ Sentences contain known words to the child. ▫ Word has same letters. - Help the child to make connection between what he read and life to encourage him to read more. ▫ Show related picture and environment to the presented word. ▫ Make a short story about the sentences, to help the child understand.

Figure 3.4: Proposed Curriculum Content

Figure 3.5 shows an example of a farm environment we created. The goal is to create a context exposing animals, such as cow, sheep, and rat, to allow learners to explore names, pictures, and sounds in an interactive environment. Letter shapes of each name are presented around the related animal, and when the child interacts with the shape it produces the corresponding sound. Thus, the child can see the shape of the letter and hear its sound at the same time. When the child ends up collecting all the letters of an animal, he will be able to hear the name of the animal and the animal's voice too. Also, there will a source of power for the child to get from the environment that protects him from the enemies. The source power is related to the animal presented (e.g. milk for the cow). The child can learn and recognize some information about the animal, such as the name of the animal, the related alphabets that construct the name, the shape of the animal, its sound and what does it produces and consumes. By this way, we exploit the use of the multimedia resources that helps making an immersive educational environment as previously discussed in the literature.

Figure 3.5: Farm Game Environment

3.3 Observations

Through our analysis of the Arabic curriculum, we found that there are multiple requirements and goals that help educators address the educational needs of the children. Although the school curriculum was updated to a newer version, we found that it lacks some of the resources which are important to make the teaching and the knowledge acquisition of attractive and effective, and help foster the learning process. Moreover, the teachers are still using the traditional teaching methods (e.g. books and power-point). As we mentioned before, learning using games has positive impact on the learning process.But there exists a large communication gab between educators, developers, and game designers. And that does not serve the idea that teachers need assistance with the development of instructional technologies from developers and game designers. To be able to cover these issues and eliminate the problems related to the school curriculum, the educators, the game designers, developers and the ministry of education should collaborate. Depending on what we found and discussed, we also think that using game-based learning will help eliminating these problems and help improving the education process in the Arab world.

Having identified issues with the curriculum organization and presentation, we are now ready to discuss the implementation of our game-based learning model based on the immersion principles, the model, and the curriculum requirements. Accordingly, the design process of the immersive educational game environment includes the following steps:

- Identify the idea and the goal of the model (section 3.4).
- Relate learning components and game mechanics (section 3.5).
- Create the storyboard and the scenes for the model (section 3.7).
- Elaborate the details of the immersive GBL model (section 3.7.1).
- Integrate all concepts together to implement the model of the immersive GBL (section 3.8).
- User acceptance tests: To ascertain the usability of the VR stimulus application.

3.4 Goal of the Model

There are two goals behind the development of this model. First, providing the learner with a systematic learning process that allows the player to construct his/her knowledge gradually through the navigation in different environments and interacting with different kinds of concepts. The concepts are related to the objects presented in each environment. Navigating through some different paths that the player has to choose from helps him/her to explore more concepts and interact with different objects and relate them together in a way that empowers him/her to build their knowledge.

Second, supporting the first goal through engaging the player in the learning process by providing the sense of "being there". We can achieve this by constructing a virtual environment which is a realistically-close simulation of the real world.

3.5 Game-based Learning Components

Game based learning is divided into learning and game play. But learning and games might be properties. For that reason, the integration of both might be a challenge. And to be able to integrate them we have to be able to identify their components and to develop a design that provides a consistence view of both of them [84]. The learning components contain the learning content, the structure of the learning content, feedback and assessment. The game components are the game play, the story, the challenges, decision making, and the presentation of the game [84]. Table 3.1 shows the components of learning and games.

Learning	Games
Learning Content	Game play
the structure of the learning content	Story
feedback	Challenges
assessment	Decision making
The presentation of the learning content	Presentation of the game

Table 3.1: Major Components of a GBL System

3.6 Model Components

The main idea is to develop a world that contains familiar environments to players in a way that when they access them, they will be immersed in some engaging activities. Figure 3.6 shows a real familiar environment which is the farm. The farm contains different kinds of real looking objects that are usually found in farms. When the child plays and interacts with these objects, he builds stories and fantasies within this environment, putting himself in a state of complete immersion. Each game environment contains some activities that allow the player to interact with its objects and construct knowledge accordingly.

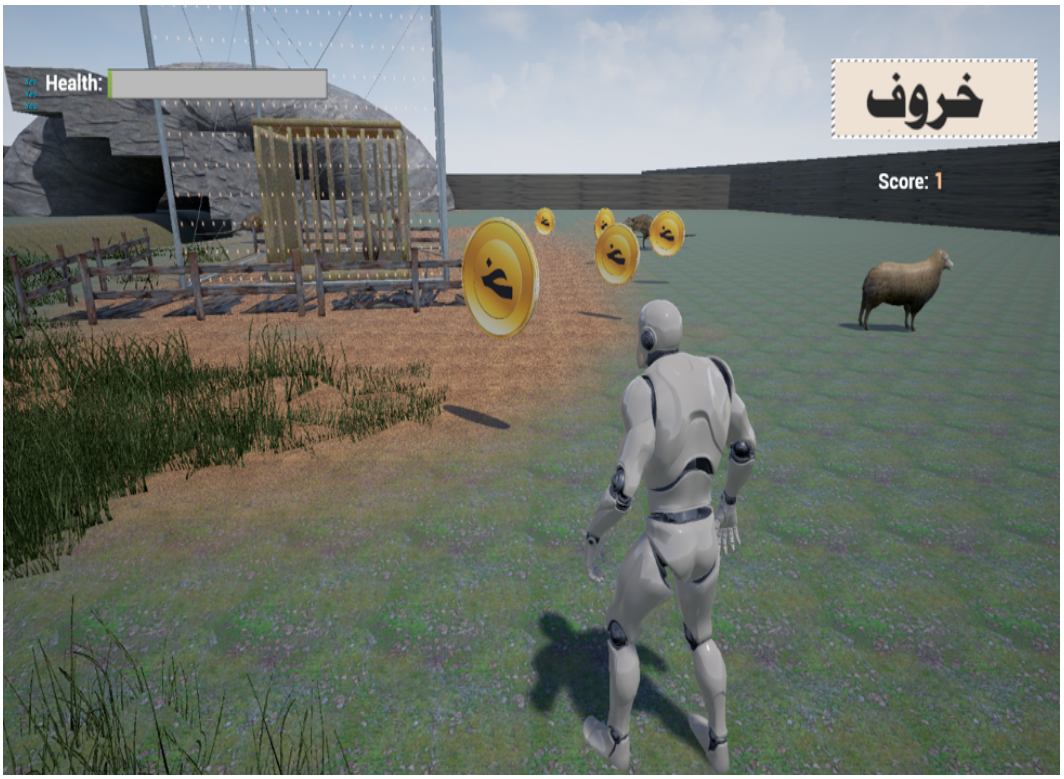


Figure 3.6: Farm Scene

To build the game-based learning model we addressed the following questions:

- What is the kind of knowledge to be learned?
- How is the learner going to discover this knowledge?
- How is the knowledge (the learning content) organized?

- How many choices given to the learner in order to provide different exploration paths?
- How are the environments scenes synthesized?
- What are possible actions the main character (learner's avatar) is capable of performing?
- What are the resources that contribute to the immersion element in the game in order to engage the player in the learning process?

The questions are represented by three dimensions which are concepts, learning process and game mechanics.

3.6.1 Concepts

As in each book taught in the schools, the selection of the knowledge to be learned depends on the level of the learner and the kind of knowledge to be acquired. By looking at the school books, we can list the outcomes and the deliveries of every lecture, and the number of the themes and the topics to reach these outcomes. GBL is providing the same content in different ways to achieve the same outcomes effectively. Hence, the learning content should be modeled as follows:

1. Concept selection: the concepts selected to be presented in the game are the same as the ones exist in the targeted school curriculum. Thus, the content of the curriculum will be mapped in the game so it can be useful as much as possible to the targeted audience who are studying that content.

2. Concept organization: GBL provides an exploration of concepts method for the players through various paths. This requires a network structure which contains nodes where every node is a cluster of concepts and ordered in a way that represents the zone of proximal development [85].

3. Concept exploration: The network structure provided by GBL allows the player to make progress in the game through paths that connect the concepts clustered nodes. This defines the actions of the player in the game.

As this research concentrates on learning the Arabic language for grade one, the concepts used are derived from the UAE Ministry of Education grade one curriculum. This set of concepts was used to synthesize familiar environments.

3.6.2 Familiar World

The normal classroom does not allow children to reflect and make sense of their own experience. They depend on the teacher to motivate, explain, help and give them feedback. The familiar environments in educational games provide contexts related to player experiences which strengthen the learning process and accelerate knowledge acquisition. Figure 3.7 illustrates some of the familiar places in the child's world that he can visit.

Figure 3.7: Familiar Environments

An experiment reported in [53] used a virtual educational game that mimics familiar environments to teach primary school children the English language. The children can interact with the objects presented in each environment by moving them and clicking on them. Also, the game provides feedback to children after they make a decision. The results showed that

the direct interactions with the game environment and its objects, including the sounds and the graphics, affected their learning positively. In addition, after observing the students reactions, the researchers noticed that the students were motivated and wanted to react and help other students who did wrong in the game.

A storyboard consists of the scenes is developed based on the child's world familiar environments and the set of concepts. Figure 3.7 shows scenes that allow the learner to explore in the game world. In addition, some other criteria besides familiarity are considered to construct a given learning environment, e.g. small numbers of concepts should be introducing at a time because of the short term memory the child has, and the balance in the used resources (aural, visual, and textual) to insure that no distractions will happen while playing and learning.

As shown in [**?**], sounds and images have an effect on the player emotions, which affect his learning accordingly. Table 3.2 summarizes the relations between visual and audio resources and what kind of emotions result from each relationship. In chapter 2, we discussed in details how we map these relationships to a game environment.

Sounds / visual Source	Visible	Invisible
High and Synchronized	Fear	
Low and Synchronized		Anxiety

Table 3.2: Emotions Matrix

When the child starts exploring the environment, he moves through the concept network structure which allows him to associate between the presented concepts. The concepts could be objects and attributes that when associated they construct the meanings and the knowledge that the player can understand and acquire. Figure 3.8 shows a sample of the learning content.

الحيوانات	الجسد	الثمار
أسد	رأس	تفاح
نمر	أنف	برتقال
فهد	فم	عنب
قرد	عين	رمان
وعل	أذن	خيار
بقرة	وجه	موز
بطة	رقبة	صبّار
جرذ	رجل	خس
ثعلب	ذراع	بصل
جمل	كف	عدس
صقر	قدم	فول
ظبي	كتف	جزر
ضب	فخذ	أناناس
قرش	اصبع	ملفوف
سمك	ظفر	شمام

Figure 3.8: Learning Content Sample

3.6.3 World Conceptual Structure

Figure 3.9 shows a conceptual structure that represents the concepts which the player need to learn in order to reach a given level of eloquence in the Arabic language. These concepts or stages are strongly related where the player cannot move forward unless he/she masters some or all of the related sub concepts of each stage.

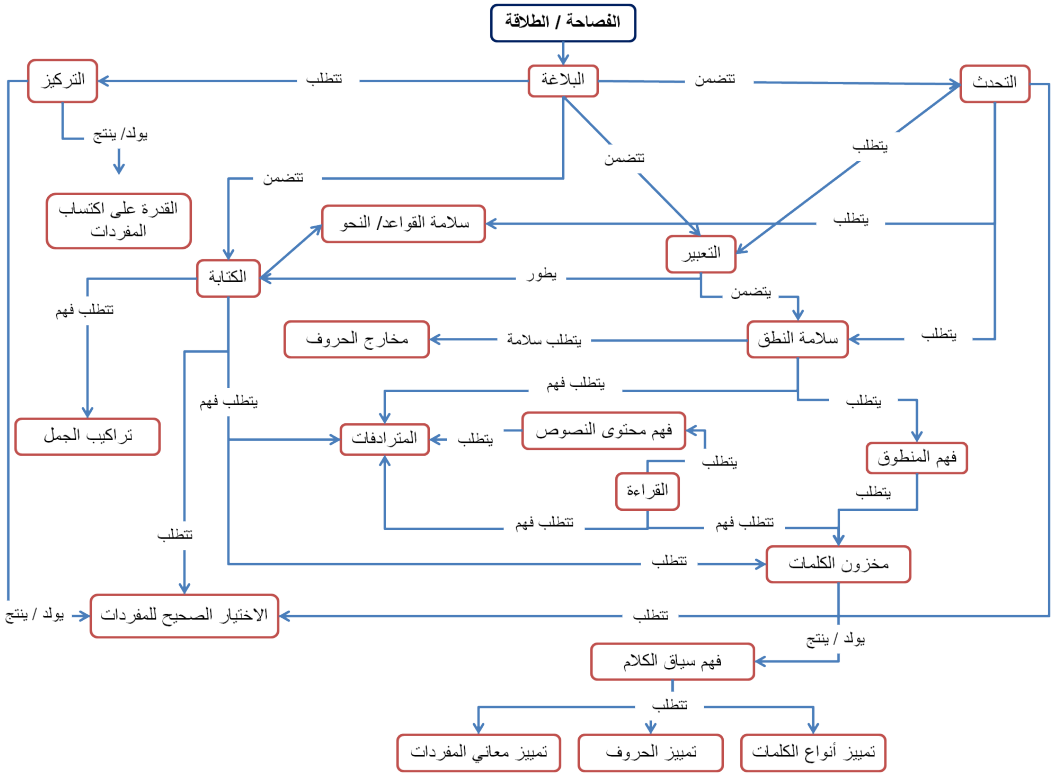


Figure 3.9: Conceptual Structure

3.6.4 Learning Process

As we discussed before, in order for the player to acquire knowledge in games, he follows the concept network structure while exploring through different paths and performing some activities. The activities that the player performs are divided into cognitive and physical activities. In a research we did previously [81] we defined both kinds of activities that the player can perform in a game in order to acquire knowledge as follows.

- Physical Activities

  We modeled the player through three classes, one class represented the player and the other two represented the cognitive and the physical actions that the player can perform Figure 3.10 shows an illustration of the player class diagram.

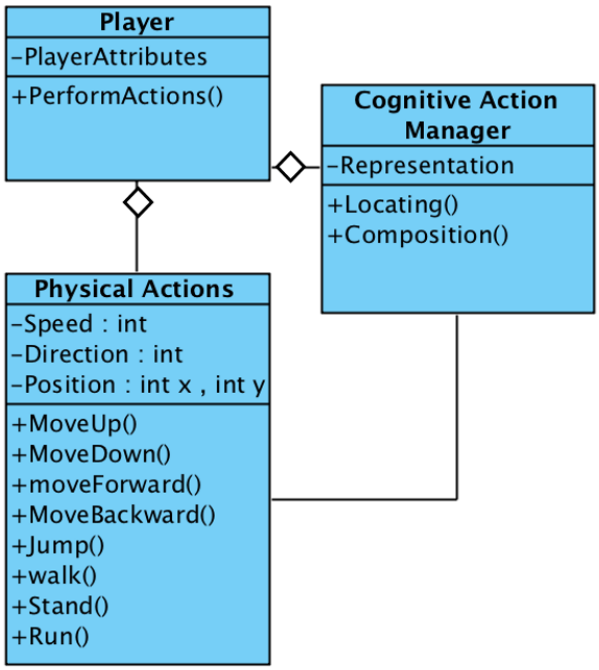


Figure 3.10: Player Class

Besides the activities the player is capable of doing, the class diagram shows some of the attributes related to him such as: position, sprite, speed, and direction.

- Cognitive Activities

  In order for the player to learn while playing he should perform some of the knowledge activities which allow him to interact with the game objects to acquire knowledge. The following state diagram 3.11 represents of the player object in a game. For the object to transit from one state to another one they must perform some activities while interacting with the other objects. The cognitive activities provided are: perception, association, recognition, debriefing, locating, composition, recalling, and classification. Physical activities are the basic movements such as: jamb, walk, and run.

  Figure 3.12 shows some of the cognitive activities and how the player can associate them to construct the knowledge. As a start we focus on the part that teaches the player

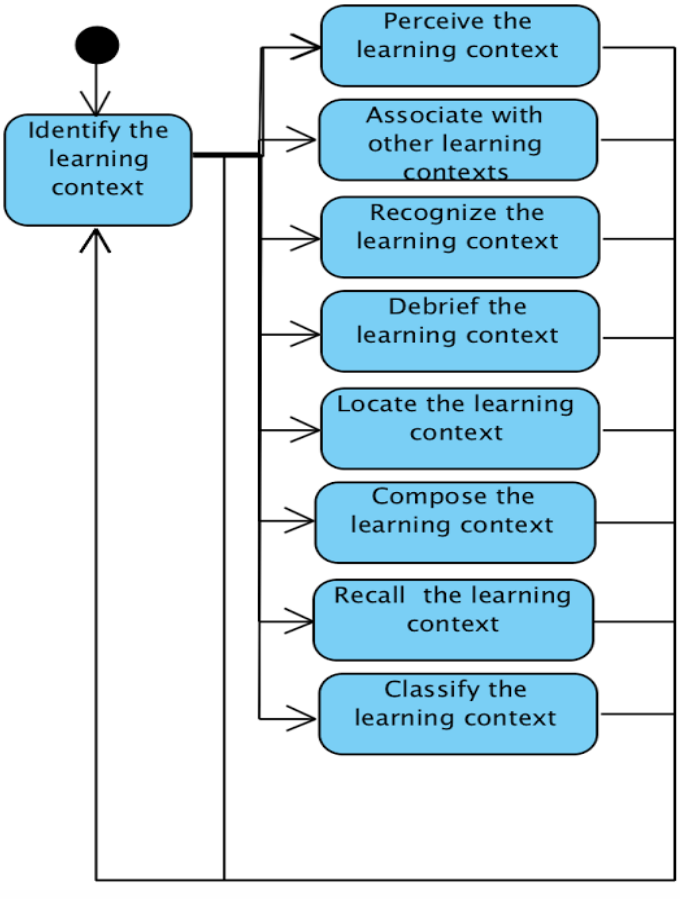


Figure 3.11: Cognitive Activities Players Perform

how to identify letters, words and some basic sentences. Through this gradual exploration of concepts, the player will acquire the basics of the language and will be capable to grasp more complex concepts later.

3.6.5 Game Mechanics

Core mechanics create patterns of repeated behavior which are the building blocks of play, and they represent the essential moment-to-moment activity of players [86]. Mechanics are represented by the actions and the behaviors afforded to the player within a game context. What the player is doing and the other entities, in response to his actions, also considered as game mechanisms. The objects in addition to the player are presented in figure 3.13

Each object is attached to specific behaviors that allow them to perform events, which

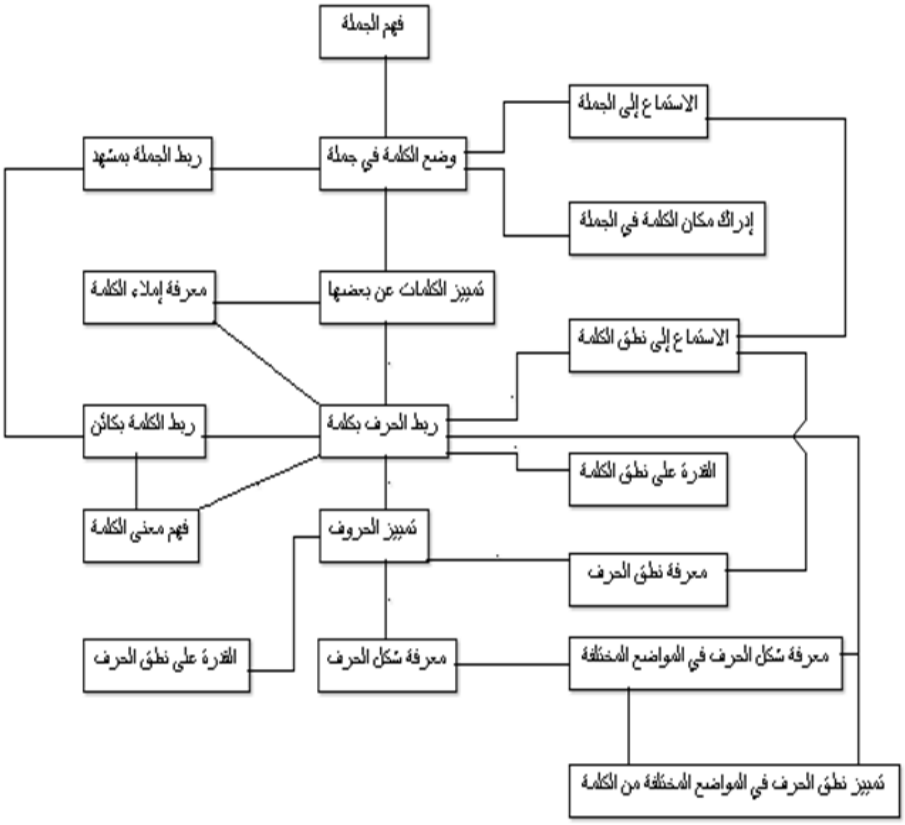


Figure 3.12: Knowledge Acquisition Activities

results in interactions among the objects and the player. Action is the way the object respond to an event. Figure 3.13 shows the possible actions the player and the other objects can perform. Figure 3.14 shows the interactions between all the game objects which forms the basis for game implementation.

3.7 Game Structure

This section will show the steps we went through to construct our model. The structure of the game describes the behavior of the player-character and non-player characters and the way they act.

3.7.1 System Overview

The goal of this project is to build an immersive and interactive language-learning virtual environment that helps children to be more engaged in the game world and acquire

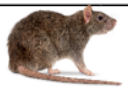
Object Name	Picture	Events
Faris		Watch the story/ Jump/ walk right and left/ run/ stand/ gain coins/ choose environments
Alphabet Coins		Rotation/ Alphabets Sound/Destroyed
Jungle animals		Sound
Farm Animals		Sound
Sea Animals		Sound
Desert Animals		Sound
Cage		Destroyed
The cage key		Destroyed

Figure 3.13: Game Objects

Object Name	Faris	Alphabet Coins	Jungle animals	Farm Animals	Sea Animals	Desert Animals	Cage	The cage key
Faris								
Alphabet Coins	Earn/listens to Alphabet sound							
Jungle animals	Animals Sound							
Farm Animals	Animals sound							
Sea Animals	Animals sound							
Desert Animals	Animals sound							
Cage	Destroy							
The cage key	Destroy							

Figure 3.14: Interaction Matrix

the linguistic knowledge and skills effectively. And the main aim of this model is to give the player the chance to learn the Arabic language through having fun and acquiring knowledge at the same time. The system is an adventure game which contains several environments the player chooses from, e.g., farm, desert, sea and cave.

Each environment has different levels of difficulties. In each level the child is introduced to a new concept (blue dots). Those concepts can be letters shapes, sounds, associated picture to certain words like picture of lion and the word lion. While playing the player starts to navigate through the world in all the directions and create connections between those concepts to recognize and understand each concept. By creating those connections the player will reach the stage of creating knowledge from those concepts. At the end of each environment level, the player is assessed on concepts just been explored. Figure 3.15 Shows an illustration of the concepts connection levels.

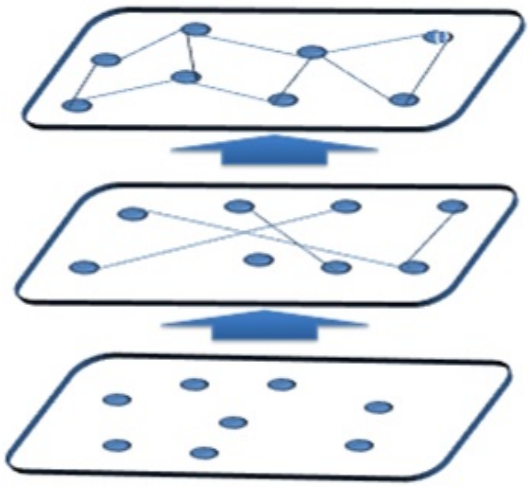


Figure 3.15: The Game Levels

3.7.2 User Interface Storyboard

One of the major parts when creating a game is creating the storyboard, which is necessary to be built before developing the prototype and building the game. It is useful mainly for writing the script of the game, developing the idea and elaborating the goals details.

The storyboard is the initial visualization of the game model that contains drawings which represent the different scenes and levels of the game. Visualizing the main idea provides a clear and comprehensive view of the game model. Storyboards are used by designers to sketch characters, scenes and ideas [87]. Figure 3.16 shows the first idea we drew on a paper prototype.

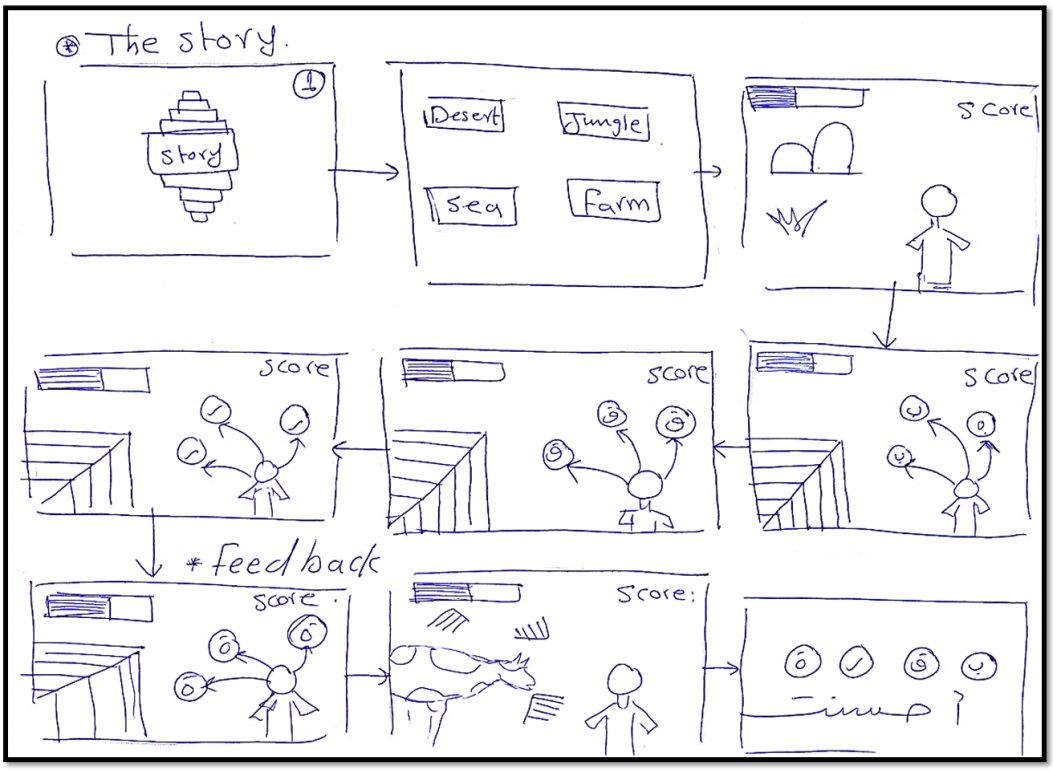


Figure 3.16: Paper Prototype

After refinement and brainstorming, the ideas are drawn on the storyboard. Figure 3.17 shows our game model storyboard.

3.7.3 Requirements specifications

The requirements of the game model prototype become clear when the paper prototype is validated. The main functionality is to make the game interactive in order to encourage the child to play, discover and learn. The player will be able to move in all directions in the game environments searching for objects and listening to their related sounds. Also, the player will be assessed at the end of each level to test the progress of his/her learning while playing the

Figure 3.17: Story Board

game. The requirements specifications are detailed in Appendix A.

3.8 Prototype Implementation

We used the rapid prototyping approach to develop our game. This approach allows us to discover requirements by experimenting with the prototype. The first step is to identify the external behavior of the system to capture the interactions between the player and the system. Figure 3.18 shows the use case diagram of our model. The main concern is to help the students learn while playing and interacting with the objects in an immersive environment that leads to player engagement and better knowledge acquisition. Developing such educational environment is an important and critical task to achieve these goals. To achieve the main and required goal while developing a game, it must go through some iterative processes such as

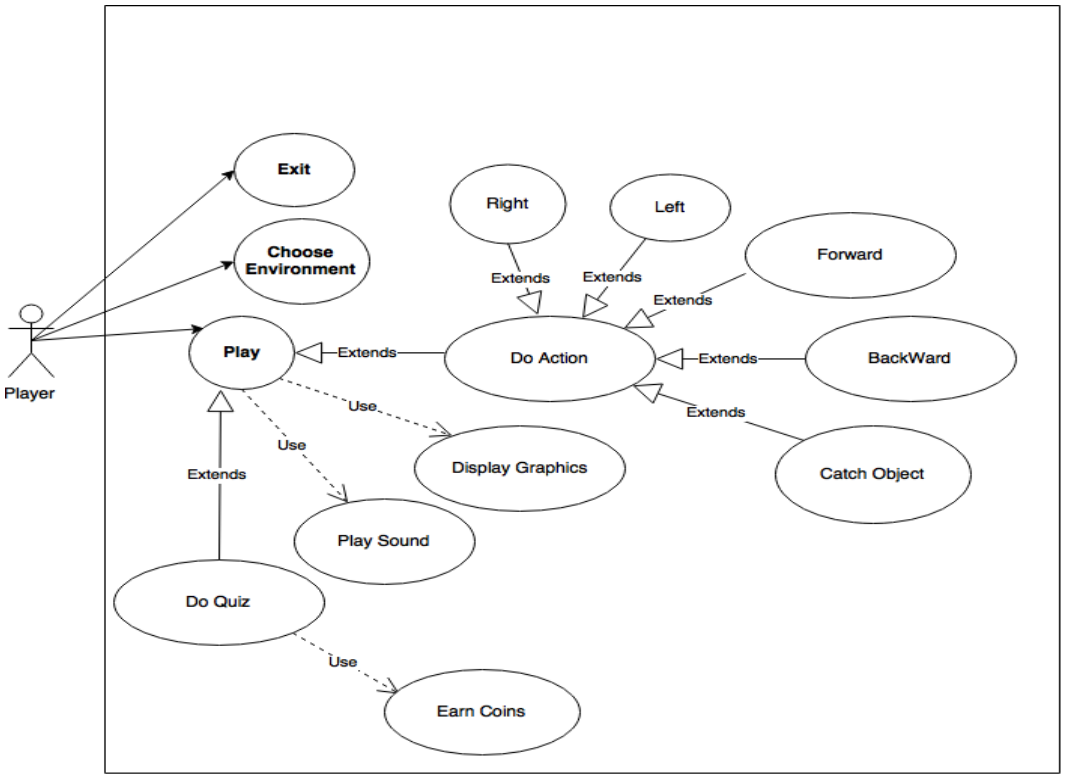


Figure 3.18: Game Model Use Case Diagram

testing and refinement. We developed the first iteration of the prototype which explains the structure of the game as shown in Figure 3.19.

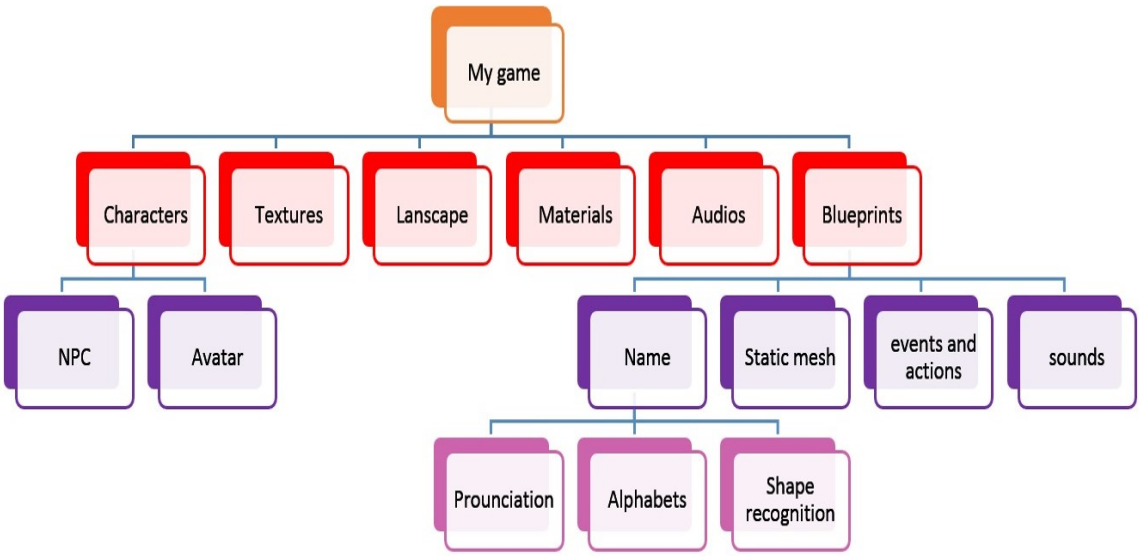


Figure 3.19: Game Structure

This structure represents the concepts provided and supported by Unreal Engine v4.10,

the engine used to develop our educational game (See Appendix A for more details about the tools used to develop the prototype.). The main resources required by Unreal Engine are the landscape, blueprints (objects), textures, characters, materials, and audios. The object is the active entity which has some behavior and animation assigned to it. Every object has a name, a static mesh, set of events and actions, and sounds. The set of events and actions are used to assign a behavior to the object. The audio gives the object the capability to emit sounds, music, or speech.

The initial scene is a story scene (Figure 3.20) where the player is able to hear the game story in order to understand what is the goal of the game and to grasp the big picture of the game process. After that the player will be exposed to the environments he must choose to be able to access it and explore (Figure 3.21). The game will start immediately after choosing the environment he wishes to explore and he will be able to navigate the avatar through the game environments and start interacting with the objects (Figure 3.22). Environments included are: desert, sea, jungle and farm. The game gives the player the chance to repeat if the avatar loses health or dies in the game.

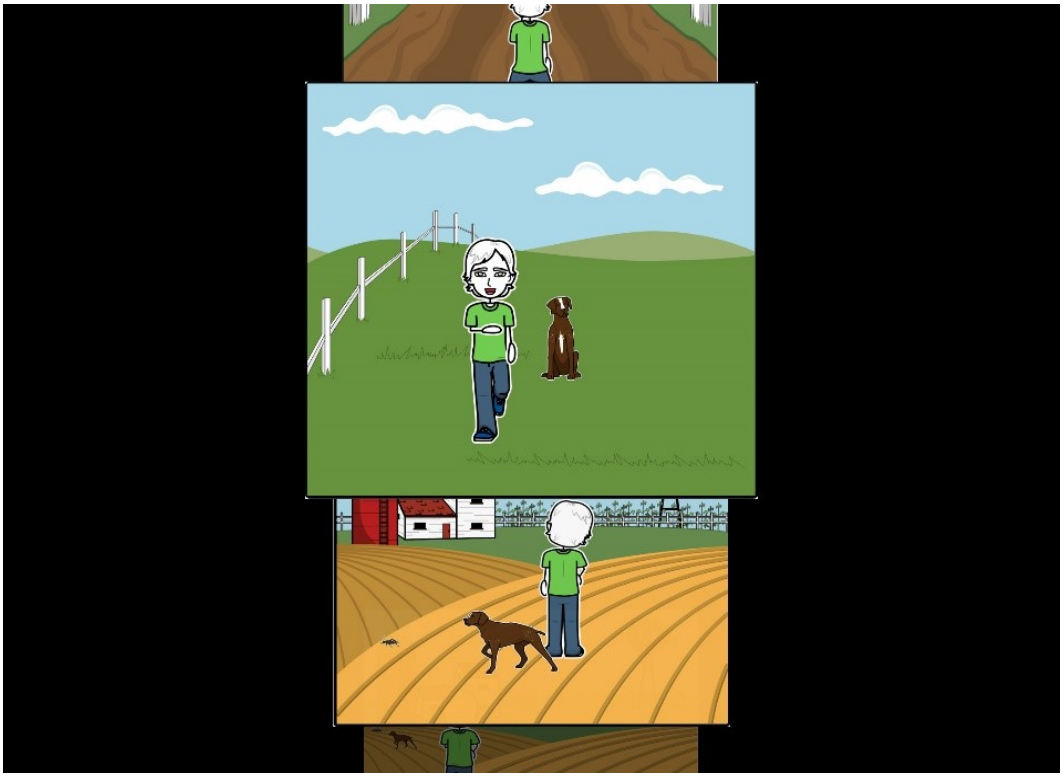


Figure 3.20: Game Story

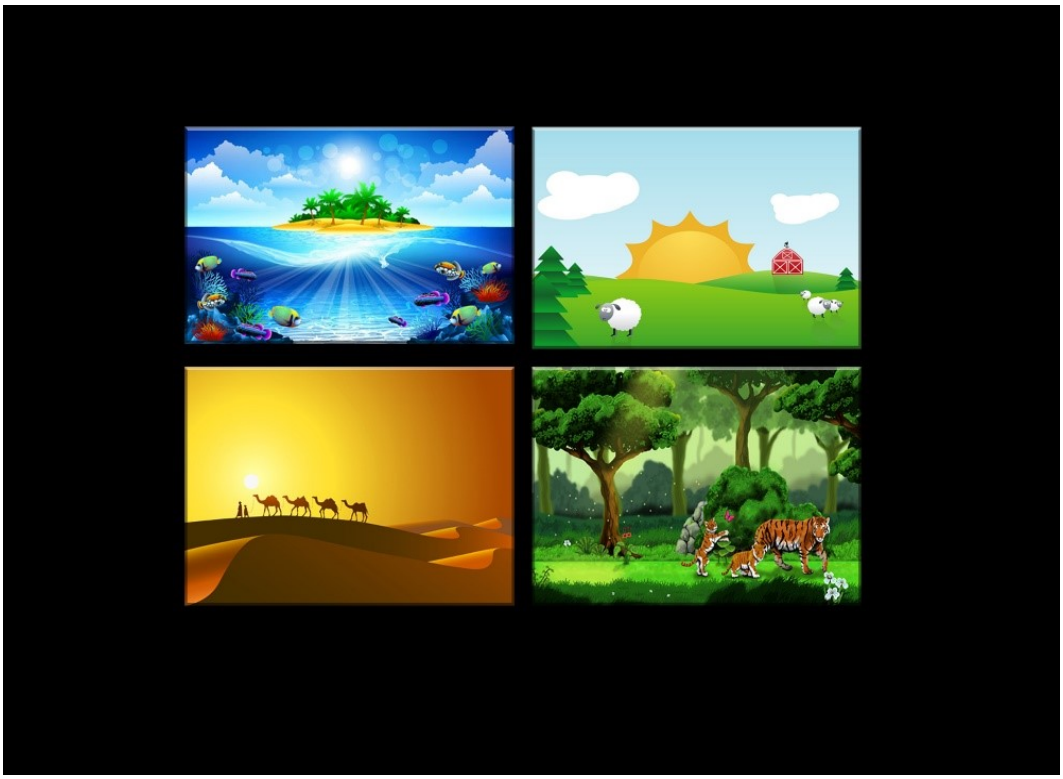


Figure 3.21: Game Environments

Figure 3.22: Player Exploring the Game

While navigating through the environments, the player learns some aspects of the linguistic concepts represented in the game. The shapes of the letters are represented with the correspond sounds, so when the player interacts with the shape he can hear the sound and the pronunciation of the alphabet. Also, the player will be able to see the words related to each creature presented in each environment. And he will be able to connect between the alphabets that form each word and relate the word to the related creature.

When the player is done with the navigation through the environments, he will be assessed by answering some questions related to the environment. If the player answered the questions the right way, he will be navigated to the next environment. The game will give the player a feedback about his answers. See Figure 3.23

Figure 3.23: Game Feedback

3.9 Summary

In our quest to implement a game-based learning system that integrates relevant content with game attributes, we carried several tasks, among them: UAE curriculum analysis, authentic virtual environment elaboration, content structuring, and game implementation. Our survey of the curriculum identified the content, the requirements, and the outcomes. The elaboration of authentic virtual environments was inspired by the content to be learned and pedagogical principles based on the structuring and conceptual organization of the content. This organization was achieved using concepts maps. Our implementation used a 3D game engine to develop the game.

Chapter 4: Experimental Analysis

4.1 Introduction

The major premise underlying immersion in the context of game-based learning is that it promotes engagement, which in turn promotes learning at a more effective rate than traditional learning methods. Our own hypothesis is "immersion increases learning". We conducted several experiments in order to test the effects on learning within the context of our implementation of an educational game and immersive worlds.

4.2 Experiment 1: Immersive Experience Assessment

4.2.1 Method

We investigated the potential of immersion supported by VR to enhance learning among children. Our goal in this experiment was to examine the effect of VR on children's learning and their attitude towards learning in a VR environment. We used our 3D game called "Faris Adventures" to test our hypothesis on the targeted audience. While playing and exploring different environments, children must catch letters of the alphabet related to the animal being displayed. While collecting the letters, the player repeatedly hears the sound of the animal and sees its picture. The game provides feedback whenever the player completes exploring a given animal. The game will play the sound "well done" when all letters making up the animal name are collected.

4.2.2 Participants

Participants in this experiment were five 6-year old grade one students from three local schools.

4.2.3 Experimental Setup

Material used in this experiment consisted of Samsung phones running the game, VR box glasses, Bluetooth headphones, and Bluetooth gamepads. The phone is installed in the VR box, which is head-mounted on the participant as a set of glasses. During the experiment, each participant must use these components together in order to move the avatar and hear the sounds synchronously. Figure 4.1 illustrates the setup.

Figure 4.1: Grade one Children Using the VR Game

4.2.4 Procedure

Participants were briefed on the activities they were to carry out and were given time to practice to familiarize themselves with the game and the use the VR glasses, the gamepads and the headphones. The experiment was carried out over four days with one session per

day. Each session consisted of three phases: a pretest, playing the game, and a post-test. Each participant played one 15-minute slot/day during which a given environment out of four different environments (jungle, sea, desert, and cave) was explored. For the pretest, participants answered a questionnaire related to the subject assumed to be learned in the game. The purpose of the questionnaire is to recognize the animals and match their pictures with their corresponding names.

Following the pretest, each participant used the VR educational game for the allocated fifteen minutes. We also observed their performance while playing to determine whether the virtual mode has any effect on their emotions and the way they act,as these are indicators of the immersion level they reach while playing. Thereafter, we administered a post-test with the same questionnaire as the pretest. Figures [4.2 - 4.3] shows a sample of the questionnaire. Results of the analysis of the pretest and post-test are discussed next.

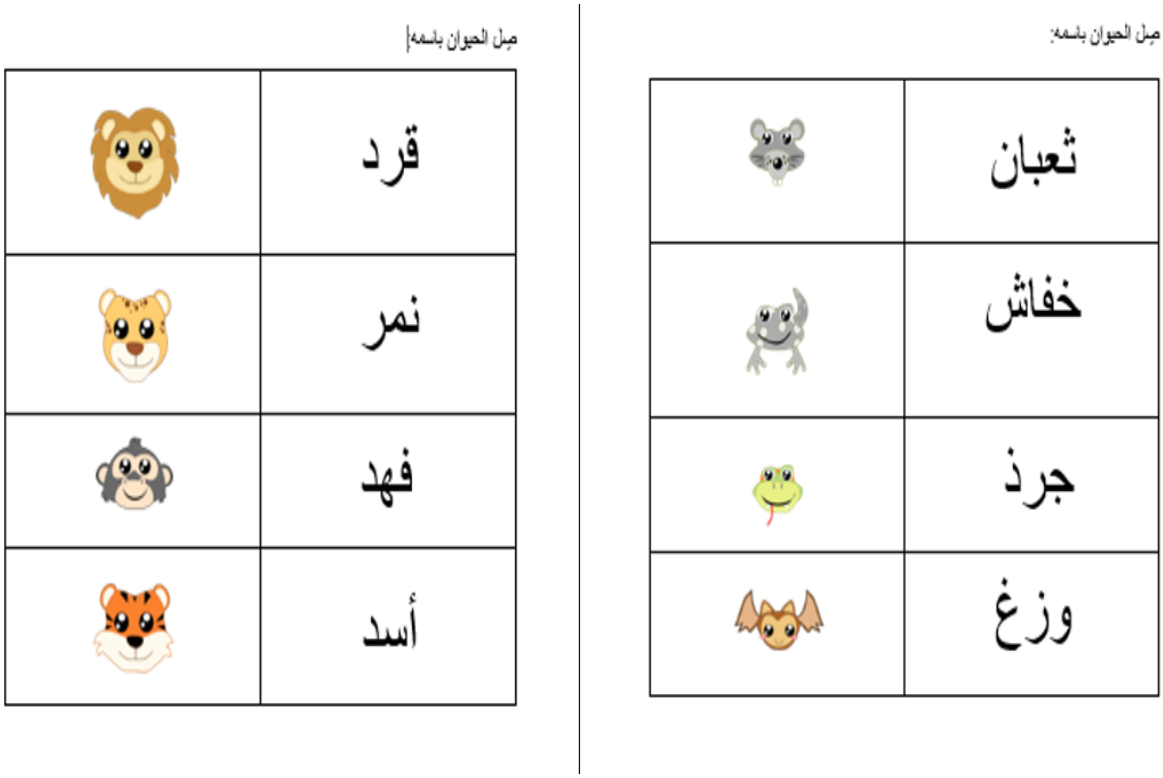


Figure 4.2: Grade One matching Test Questionnaire Sample

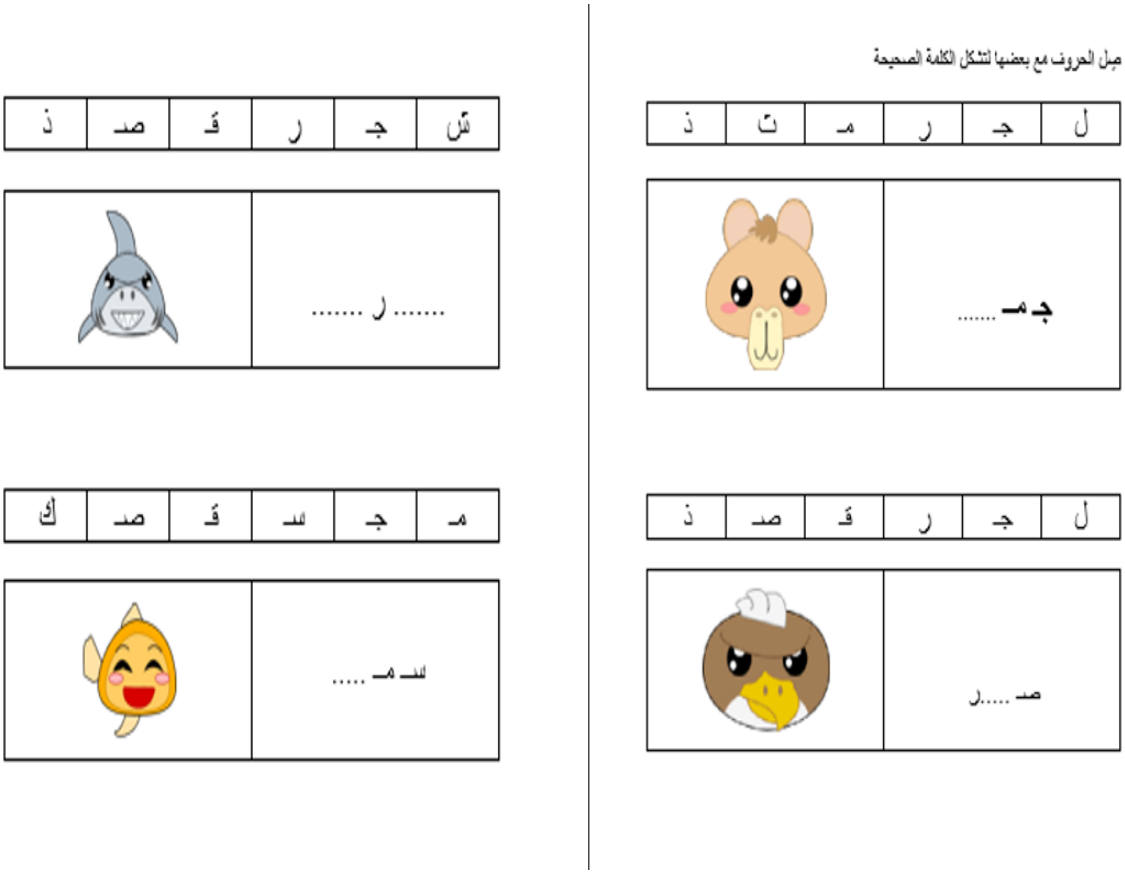


Figure 4.3: Grade One Spelling Test Questionnaire Sample

4.2.5 Results

We collected the following observations about the physical behavior of the participants while they were playing our 3D game, in addition to a "Roller Coaster" 3D virtual game downloaded from applications stores.

- Head motion
  - Most of the children started to move their head around a lot and they did not stop doing so until they got the glasses off. One of them only stayed focused on one path (the path that the avatar was moving on).
- Vocal reactions
  - The children were talking most of the time describing what they were watching in the game:

    - The children described the objects, their colors and their movements:
        - There are two men wearing red and green.
        - The plane is not moving.
        - The train stopped moving.
    - The children started to talk with the objects in the game.

- The children mood (No reaction, excited, frustrated)
    - The children were excited to play the virtual game, and once started, they moved their heads everywhere to explore the world and recognize every single object they could interact with. One of the children was frustrated while playing because he lost in the game environment and could not find the letters; then when once he gained some familiarity with the game, he kept on playing.
- Movement of the hand (slow, moderate, fast)
    - Some of the children started moving their hands slowly at the beginning and they hesitated to move ahead; they did not know where to go from the start, because the place was wide-open and they were afraid that enemies were going to hit them. Also, some of them moved their hands fast, because of their rash personality and they immediately chose quickly a spot to start with and discover.
    - The children started moving their hands trying to touch the objects inside the game.

      Figures [4.4 - 4.7] summarize level of head and hand motions, respectively.
- Reactions to the content:
    - Pretest: the students did not recognize the animals shapes except for the fish and lion. Also, they could not be able to construct the words correctly and read them properly, and they could not remember some alphabets presented to them.
    - The learning phase: The kids played the in the environments of the game. After

that they were exposed to a test to evaluate their ability to recognize the animals and spell their names with the correct related alphabets.

- The post-test: The results showed that the kids were able to recognize the presented animals and were able to spell their names and match each animal to its related name. They were able to remember most of the alphabets, because some of the alphabets were difficult to remember immediately and easily. Figures [4.8, 4.9] shows the results of the pre-test and post-test of this experiment.

All the observations indicate that, as we discussed in the previous sections, the children felt the feel of presence and were engaged in the game. The children showed all the immersion types in their behaviors, the sensory, the imaginative, the challenge-based and the feel of presence as they play in our immersive environment.

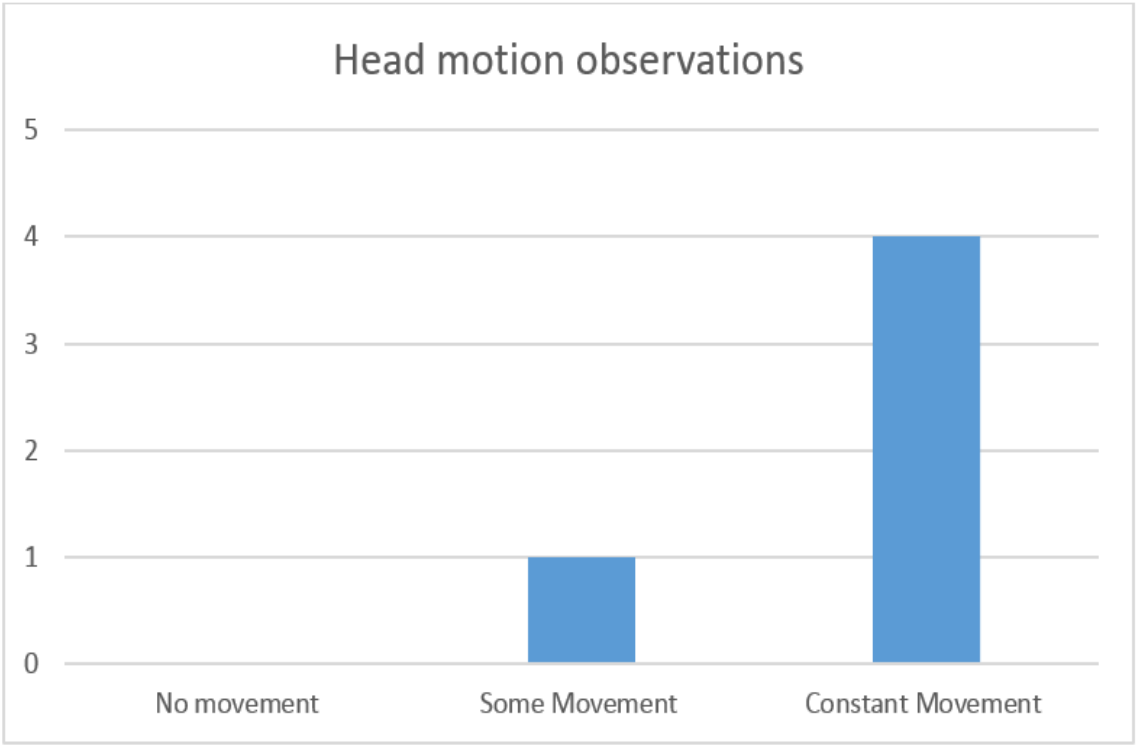


Figure 4.4: Observations of Children's Head Motions

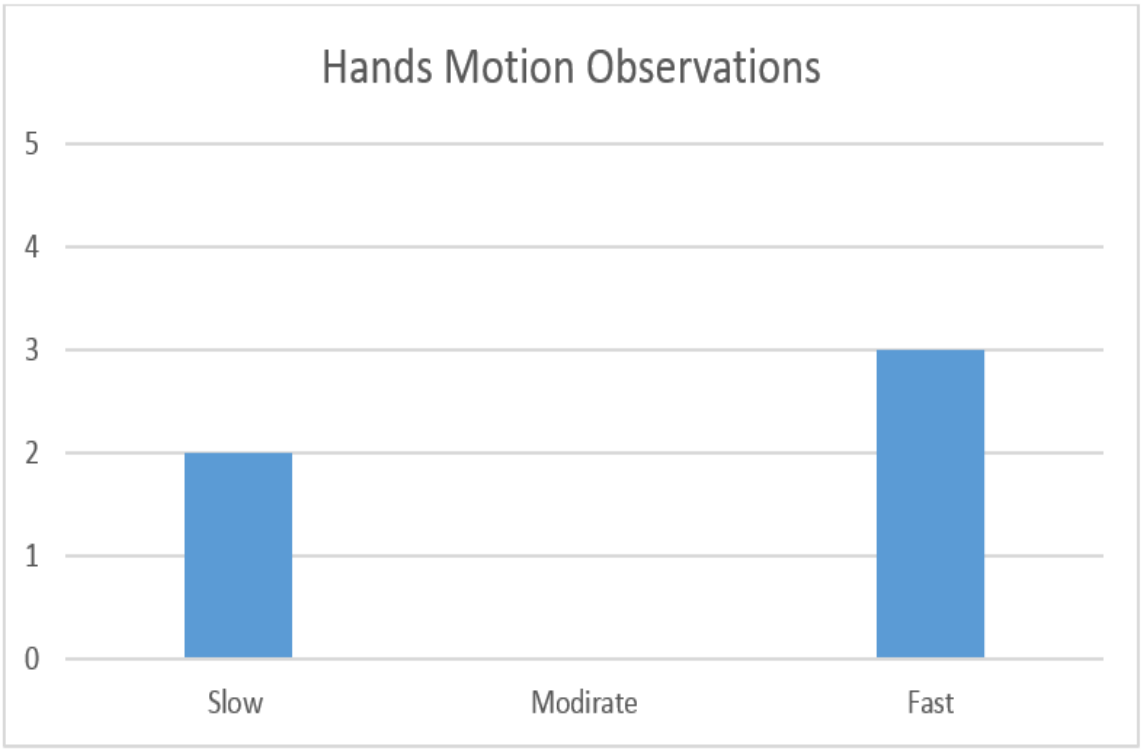


Figure 4.5: Observations of Children's Hands Motions

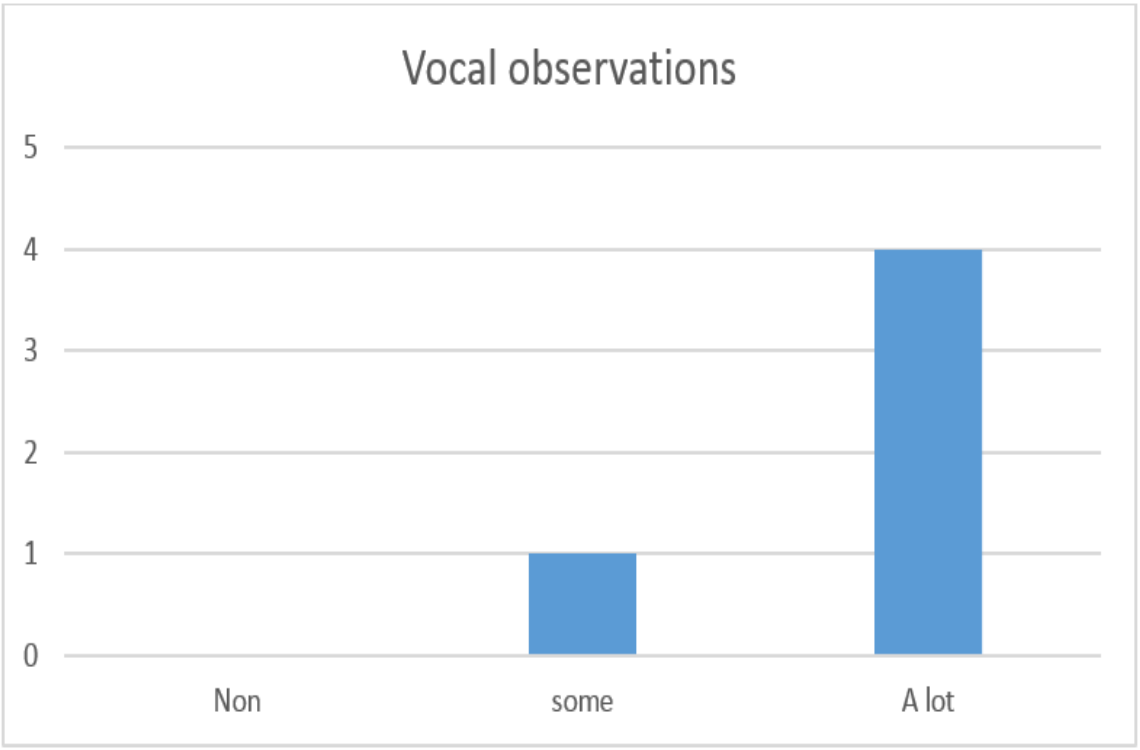


Figure 4.6: Observations of Children Vocal Reactions

Figure 4.7: Observations of Children's Moods

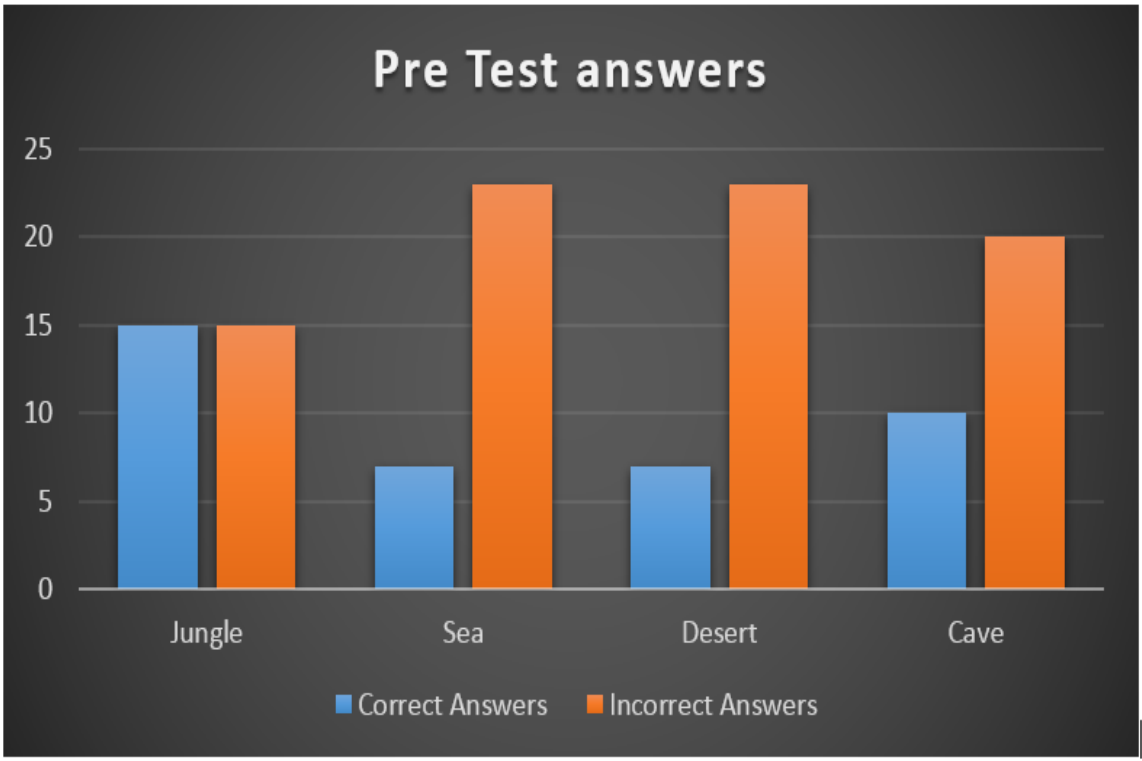


Figure 4.8: Pretest Results

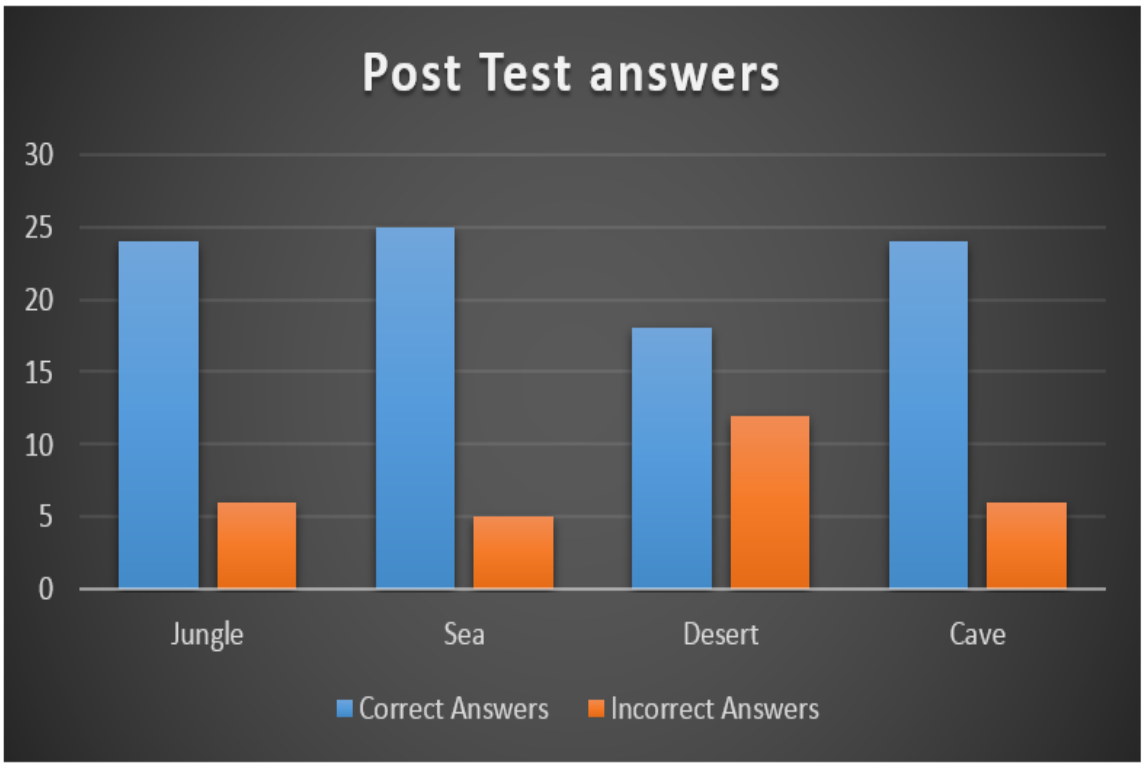


Figure 4.9: Post-test Results

4.3 Experiment 2: Learning Effect Testing

4.3.1 Method

We investigated the potential of our game content to improve learning among the 3 to 7 years old children. The goal of this experiment was to examine whether the way the content we developed including the concept map is presented in the game has an effect on children's knowledge acquisition and attitude towards learning using educational games. We used a 2D version of our "Faris Adventures" to test our hypothesis on the targeted audience. While playing and exploring different environments, children must catch letters of the alphabet related to the animal being displayed. While collecting the letters, the player repeatedly hears the sound of the animal and sees its picture. The game provides feedback whenever the player completes exploring a given animal. The game will play the sound "well done" when all letters making up the animal name are collected.

4.3.2 Participants

Fifteen grade one students participated in this experiment. Their age was between 6 years.

4.3.3 Experimental Setup

Material used in this experiment consisted of Samsung phones running the game and headphones. The child must use them all in synchronization in order to move the game characters and hear the sounds synchronously.

4.3.4 Procedure

The participants were divided into two groups, a control group and an experimental group. The control group was instructed using the traditional educational instructional methods and the experimental learned the content using the 2D game. We explained to the children what they are going to do and let them practice for a few minutes to get the feel how to play the game. Then they played for 15 minutes. The experiment was performed of a period of two weeks. Each day the children carried out one session to play with one out of four different environments (Jungle, sea, desert and cave). Each session of both groups was divided into three phases: the pretest where the children answered a questionnaire related to the subject being taught. The purpose of the questionnaire is to recognize the animals and match their shapes to their correct names. Figures [4.2 - 4.3] shows a sample of the questionnaire. Then comes the learning phase where the children used the 2D educational game and started learning the content while playing. Thereafter, we tested them with the same questionnaire used for the pretest to examine if there is a difference in their performance and if the game has an effect on their learning and recognition processes.

4.3.5 Results

We used the number of the correct answers reported from both the control and the experimental groups to compute the effect size (d value). And the results stated that:

For the Jungle environment test the effect size is 0.12 which is considered a small effect size. It means that students learning was not affected by using the game. It's obvious because the jungle environment was familiar to all the students and they recognized most of the animals. Also, 80% of the students were able to match the animals with their names correctly.

For the sea, the cave and the desert environments the effect size went above 1.5 which is considered a high effect size. As in the experimental group, the students were not able to recognize the animals shapes and did not match them to their correct names until they played the game and acquired some knowledge about the animals. In contrast, in the control group the students were not able to recognize the animals before and after the lecture given in the class. Results of the pre-test and post-test of the both control group and experiemental groups are shown in figures 4.10 - 4.13.

4.4 Experiment 3: Immersive Environments Characteristics

4.4.1 Method

We investigated the potential of VR to engage and immerse players (learners) in the learning process. Our goal from this experiment was to test the characteristics of our 3D game environment that contribute to immersion. We used our game 3D VR "Faris Adventures" to be played by adults.

4.4.2 Participants

Twenty college students (ages between 19 and 23) participated in this experiment.

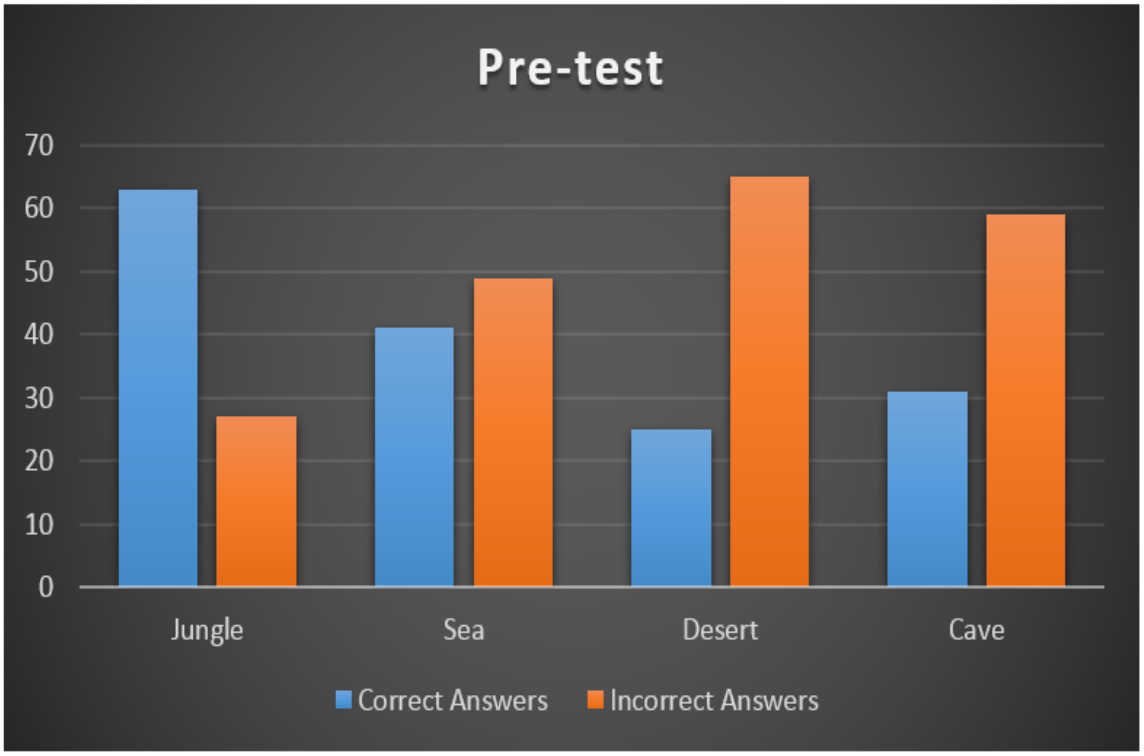


Figure 4.10: Experimental Group Pretest Results

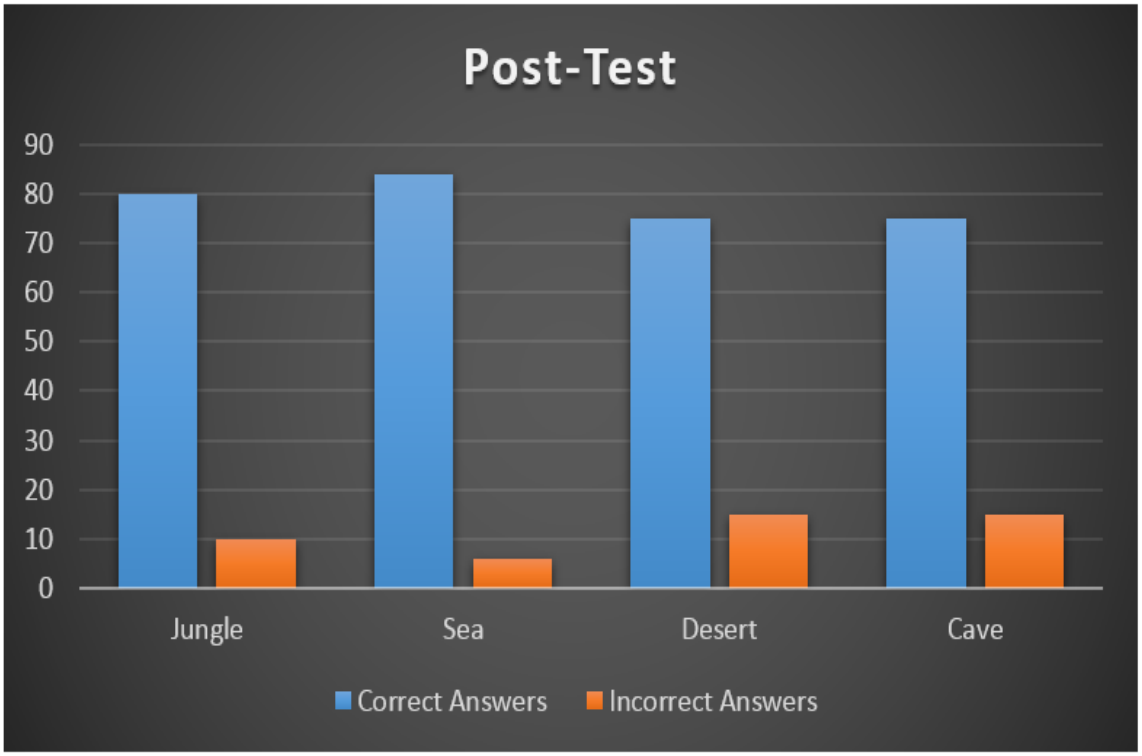


Figure 4.11: Experimental Group Post-test Results

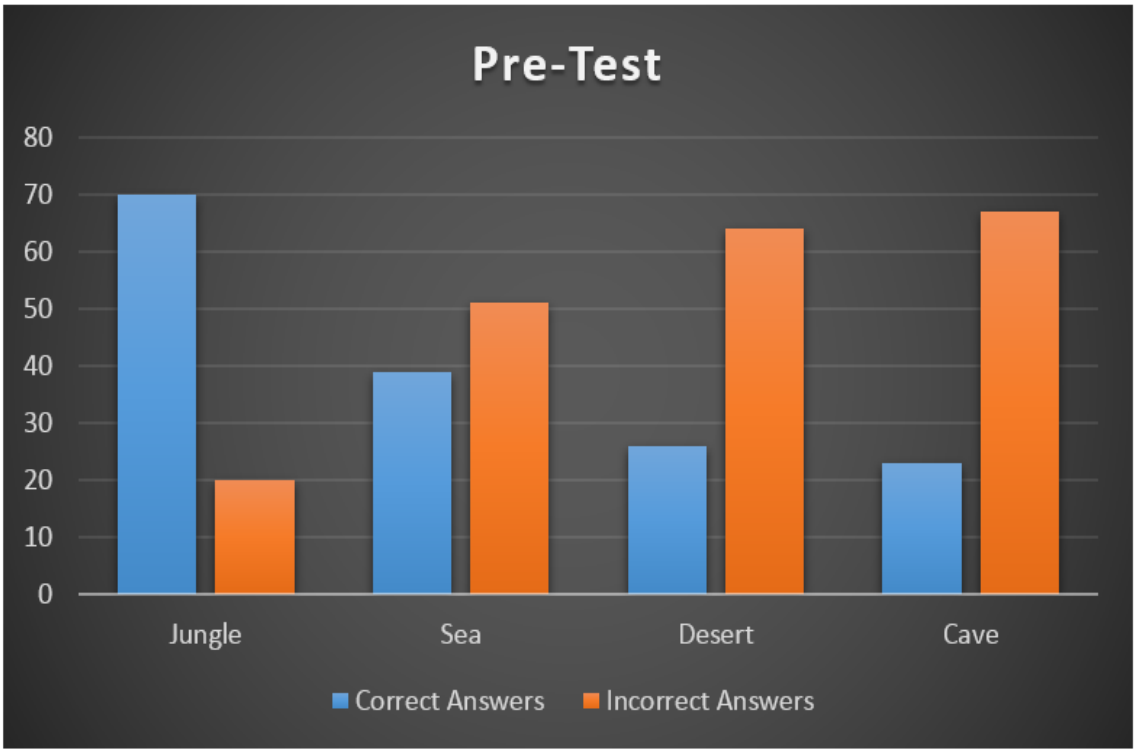


Figure 4.12: Control Group Pre-test Results

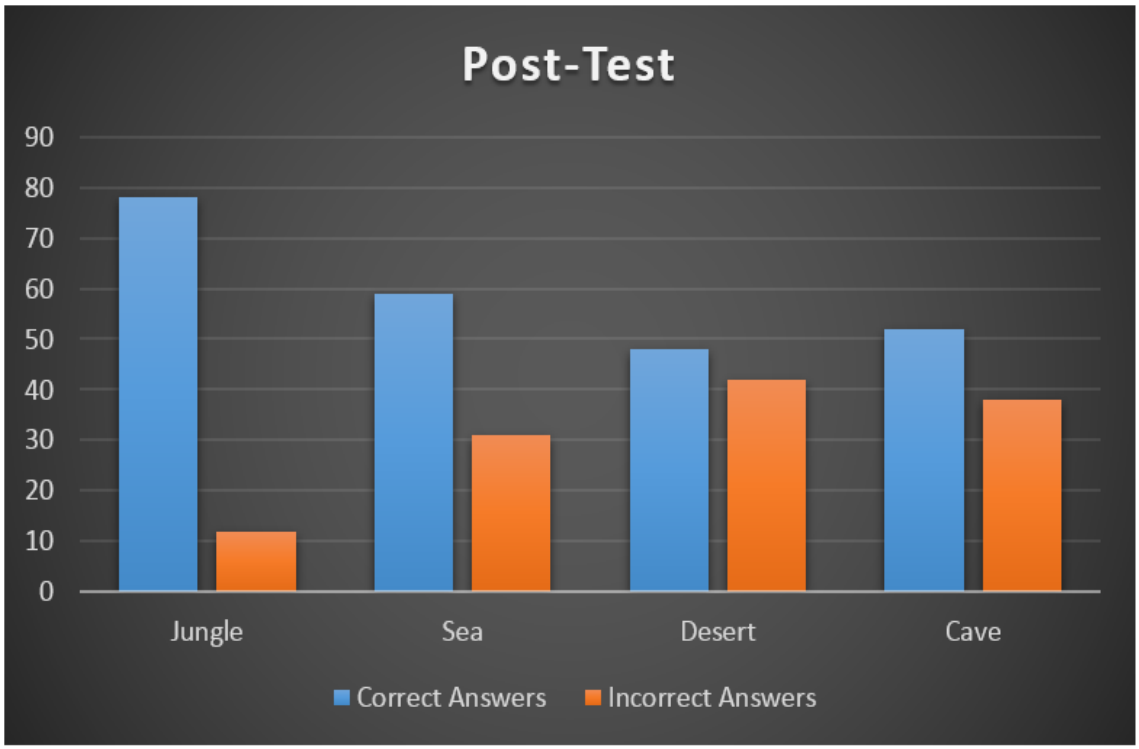


Figure 4.13: Control Group Post-test Results

4.4.3 Experimental Material

Materials used in this experiment were Windows desktop running the game, VR Oculus rift, Bluetooth headphones, and keyboard. The subjects must use them all in synchronization to move the avatar and hear the sounds synchronously.

4.4.4 Procedure

The game was set up to execute in VR mode. We explained to the players what they are going to do and let them practice for a few minutes to get the feel of how to play the game and use the VR glasses, the keyboards and the headphones. Then the subjects started to play for 15 minutes. The experiment was carried out over a two-week period, each day the subjects carried out one session to play with one out of four different environments (jungle, sea, desert and cave). At the end, the subjects filled a questionnaire, whose purpose was to measure questions related to characteristics of VR that contributes to immersion and engagement. We also observed their performance while playing to see whether the virtual mode influenced their emotions and the way they act, as these can be indicators of the immersion level they reach while playing.

4.4.5 Results

Figure 4.14 show the answers of the subjects to the questionnaire questions.

The results showed that:

- 50 % of the subjects agreed on forgetting about time passing while playing the game.
- 70 % of the subjects become unaware of their surroundings while playing the game.
- 50 % of the subjects agreed on experiencing an altered sense of time.
- 55 % of the subjects were not sure if they forget worries about everyday life while playing.

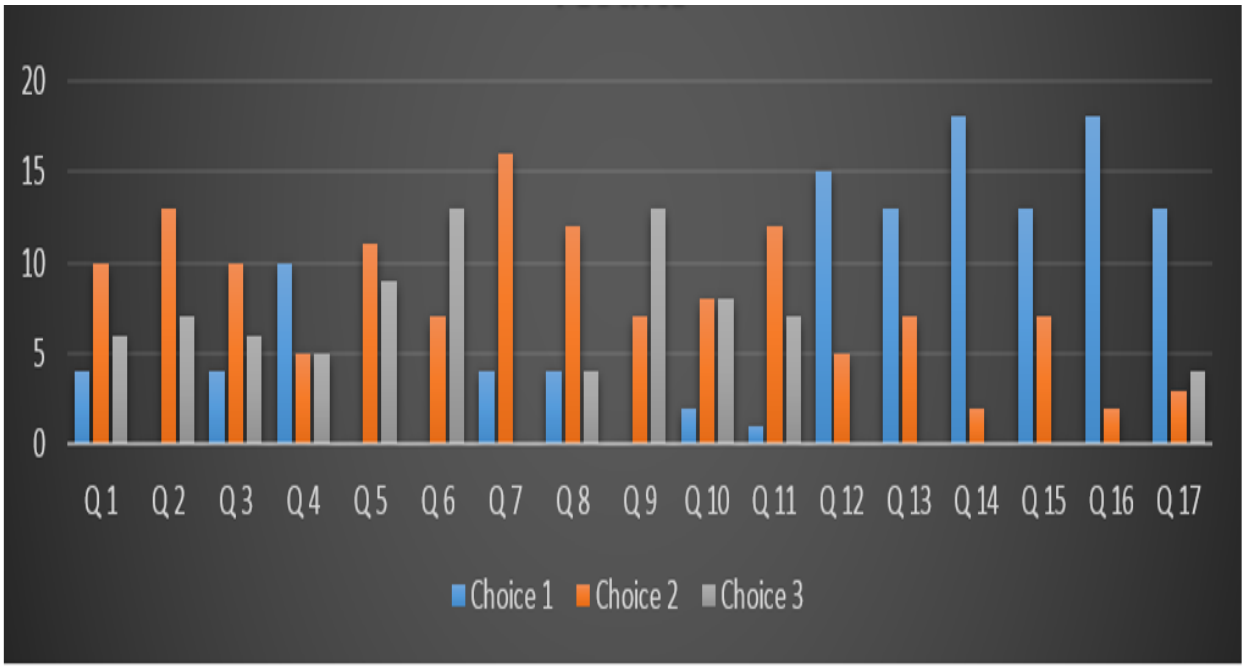


Figure 4.14: A Graphical Illustration of The VR Experiment Results

- 70 % the subjects agreed and strongly agreed on becoming involved inside the game.
- 70 % of the subjects said it was easy to play the game.
- 90 % of them felt inside the game.
- 70 % of the subjects agreed that the game environment was somewhat familiar.
- 70 % of the subjects were comfortable while using the device.
- 90 % of the subjects agreed that the pictures used in the game are suitable for a 4-year child.
- 69 % find it easy to interact with the 3D objects and elements of the game.
- 88 % agreed on having better understanding of the linguistic concepts.
- 70 % agreed on having better understanding of the linguistic structures.
- 99 % of the subjects felt that the 3D simulated environment provided by the system is realistic.
- 70 % of the subjects feel that the 3D simulated environment makes them concentrate

more while learning.

- 99 % of the subjects are willing to continue using the game in the future.
- 5 % of the subjects recommended to use the advice as a learning tool while 90 percent welcomed the idea.

The questionnaire sample can be found in the appendix B.

4.5 Summary

In the immersive experience assessment experiment, signs of being immersed in the game environment were observed from the children behavior. The children were interacting with the game by moving their heads, hands and having conversations with themselves while playing. Also, the results of pre and the post-tests showed a significant change in the learning effect of the children. They performed better in terms of choosing the correct answers.

The results of the learning effect testing experiment showed that using the educational game led to higher performance for the experimental group. However, for the control group, where the students were instructed using traditional learning process, there were no differences found in the performance.

The experiment to test the immersive environments characteristics by adults showed that all the attributes included in the game environment contribute to the player immersion and feel of the presence.

Finally, the results of all the experiments confirmed our hypothesis and results reported in the literature, that immersive educational games support effective learning and increase the level of engagement of learners using educational immersive environments.

Chapter 5: Conclusion

5.1 Summary

Our major contribution is the construction of a model and its implementation to promote immersion and effective learning. To address the issues related to the effectiveness of immersive environments on learning, we investigated existing models of immersion and identified the main dimensions of immersion. We summarized existing research on the effectiveness of immersive game environments and extracted the attributes that contribute to immersion in games. Moreover, we selected three dimensions of immersion that when included together with the learning activities in a game they cause engagement, motivation, and better learning. These are: sensory immersion, imaginative immersion, challenge-based immersion, and presence-based immersion. The literature on immersive educational games introduced models which contain attributes that cause immersion, but none of them mapped these models to an educational game. Also, the models did not address one of the important factors that contribute to immersion which is "the feel of presence". Our investigation allowed us to synthesize our own model to support immersive features in educational games.

To develop a systematic game-based learning approach, we sought to capture basic learning activities and to identify the extent of the learning content. Thus, we analyzed the United Arab Emirates Arabic curriculum from which we extracted requirements, goals, outcomes, and content to be used by educators to meet the needs of the children educational levels. The analysis provided a basis for structuring and conceptualizing various authentic learning environments that embed the required content and support pedagogical principles.

The proposed game consists of a set of environments. Each environment contains activities that allow the player to interact with its objects and construct knowledge accordingly. Even though intuitive, player interactions are guided by the learning model we built based concepts selection, organization and exploration. As this research concentrates on learning the Arabic language, the concepts used are derived from the UAE Ministry of Education grade one curriculum. This set of concepts was used to synthesize familiar environments.

In their quest to acquire knowledge, players navigate a concept network structure, while exploring different paths and performing activities. The concept network structure is represented by a concept map we developed to capture hierarchical relationships among concepts. The navigation and exploration processes are implemented by game mechanics which are represented by the actions and the behaviors afforded to the player within a game context.

The implementation of the game followed the software prototyping approach. We described the external behavior of the system with a use-case diagram. The design of the game was carried out in stages, including (1) the elaboration of a storyboard, (2) the description of the behavior of the player-character and non-player characters and their interactions, (3) the construction of the graphical resources and content, (4) the creation of the game triggers to capture the selected immersion dimensions, (5) and the actual coding using the UNREAL game engine.

Finally, we performed three different experiments to assess our approach to immersion and learning. The results of these experiments showed a difference in the learning process as a consequence after using the educational game. The calculated effect sizes confirmed that using educational games allow the players to acquire knowledge about the material learned and engage them in the learning process, which enhances the learning process. Therefore, the results demonstrated that our 3D virtual games triggers immersion, and that it has a positive effect on learning.

5.2 Future Work

The next step after addressing how to immerse students inside the learning environment, is to support the collaborative learning inside one virtual environment. It helps learners to discuss and understand the topic being learned together which facilitates the process of acquiring knowledge. Also, interacting with the objects being taught and the elements inside the collaborative environment helps the players relate the linguistic concepts together with their related aspects. Collaboration and interaction can be together as factors to support the learning process while playing games.

Appendix A: Detailed Requirements Specifications

A.1 Functional Requirements

Related to the use case diagram, a set of functional requirements is developed. These are:

FR: 1. The system shall provide various options to the player.

FR: 2. The player shall have the option to start the game.

FR: 3. The system shall display the game environment.

FR: 4. The player shall select a learning environment.

FR: 5. the system shall maintain competency levels.

FR: 5.1. The competency levels shall be structured according to prerequisites.

FR: 6. The system shall display the competency levels of the player:

FR: 6.1. The system shall inform the player of his/her competency level.

FR: 6.2. The player shall be able to transfer to the next allowable level.

FR: 7. the system shall allow the player to navigate back to previous levels.

FR: 8. the system shall enforce the prerequisites among the competency levels.

FR: 9. the system maintain the highest scores of the users for each level.

FR: 10. The player shall have the option to finish the game.

FR: 11. The system shall display the final level attained by the player.

FR: 12. The system shall maintain an account for each player

FR: 12.1. The account shall have a unique name

FR: 12.2. The account shall contain progress information

FR: 13. The system shall detect deficiencies in the player performance.

FR: 13.1 The system should report the deficiencies

FR: 13.2 The system should recommend actions.

FR: 14. The system shall maintain the information about the progress of the user.

FR: 15. The system shall provide feedback to the player.

FR: 16. The system shall reward the players.

A.2 Product Services

This game will provide the following services to the player:

- Several of environments to explore and learn from.
- Navigation through searching for and interacting with objects and collecting concepts.
- The ability to go back and forth between the game levels.
- Variety of concepts, such as those related to authentic environments children come into contact regularly.
- Shapes, sounds, and images, and their connections to elaborate new cognitive structures.

A.3 Operating Environment

The game will be running on any personal computer operate on Windows and Mac operating systems. It will be running on smart phones like Samsung smart phones(S3, S4, Galaxy Note2), apple iphones (iphone4, iphone4s, iphone5) and Tablets like Samsung (Galaxy Note 10, Galaxy Note 8), apple ipads and ipods, or any other device that uses the Android operating system.

A.4 Error Handling

We designed the game in a systematic way with a structured interface that clearly defines the legal actions. Such a structured interface allows the player to perform only actions allowable by the game, thus minimizing the risk of errors.

The system will provide familiar objects and actions for the child for avoiding miss understanding of the meanings of the words and sentences. That will be handled by recognizing, searching and surveying for the words and sentences that the child already knows. The system will show the child the object that he can play with to avoid repeating by mistake the playing with the object by mistake. That will be handled by putting a cage on the object that the child need to play with, then open the cage for the object that the child already played with.

A.5 Foreseeable Functional Changes and Enhancements

Adding more excitement and challenges to increase the level of sophistication of the player is one highly desirable feature. Another desirable feature is for the game to support multipliers , such as having two players compete on the same level. We can also create a ranking board of all our end-users (players) scores and levels to show off the success of the players in a leader board.

A.6 Non-Functional Requirements

NFR: 1. the system shall be available all the time.

NFR: 2. the system shall be designed using Game-maker.

NFR: 3. the system graphics shall be designed using image editors (Adobe Photoshop Cs3, Spriter 2D Animation Tool and Sai Painting Tool)

NFR: 4. the game application shall be running in at least one of these platforms: Windows

OSs, Mac X OSs and Android OSs smart phones and tablets.

NFR: 5. the system shall be responsive.

NFR: 6. the game shall be fun.

NFR: 7. the feedback shall be encouraging.

NFR: 8. the feedback shall maintain the enthusiasm of player

A.7 Product Requirements

- Reliability: The system must have less than 1hr downtime per three months, as known the at the Reliability associate with availability so the system should not take more than 1 hour to be repaired in case it is out of service.
- Portability: The software needs to be able to run on one specified operating system, for example Windows XP.
- Memory size: It should easily be able to run on Windows XP system with 128 MB of RAM.
- Response time: The response time spending on retrieving information from database should be not more than 2.0 seconds.

A.8 Development Requirements

In this project we are using ArgoUML software tools to draw UML use case diagrams and class diagrams. We are using Gantt Project tool to draw Gantt charts for project management part. We are using Adobe Photoshop to convert to digital images for the prototype and graphics. Game Maker studio is used for developing the game.

A.9 Foreseeable Non-Functional Changes

The player can challenge with his/her friends in multiplayer mode online. We will provide more languages for the game to be used in the interface and for learning. That will be done by adding a list of languages that the child can select from.

Appendix B: Tools

To implement the game model, we used some software shown in Figure B.1 ; Unreal Engine, Golden Wave sound editor and Photoshop CS6. Our model is implemented using Unreal Engine v.04, which is a 3D- built in software that allows the developers to drag and drop the blocks of codes and connect them in order to activate the characters and give them some functionalities to perform. Also, it allows the developers to import images, textures, 3D models and sounds. The Unreal Engine contains; blueprints which represent classes, sounds, meshes, maps, materials, particles and shapes. Also, it contains ready to run demos. As shown in figure B.2. In Unreal Engine, textures, sounds, materials, shapes, properties and behaviors can be assigned to the objects using Blueprints. In addition, Unreal Engine contains some painting and sculpting tools that allow the developers and designers to build and construct the game environment from scratch. The engine also allows the developers to import 3D models as objects and assign functionalities to them. The game GUI including the graphics is designed using Adobe Photoshop CS6. We used the sound editor, Golden Wave, to edit the sounds that are assigned to the player.

Figure B.1: Tools

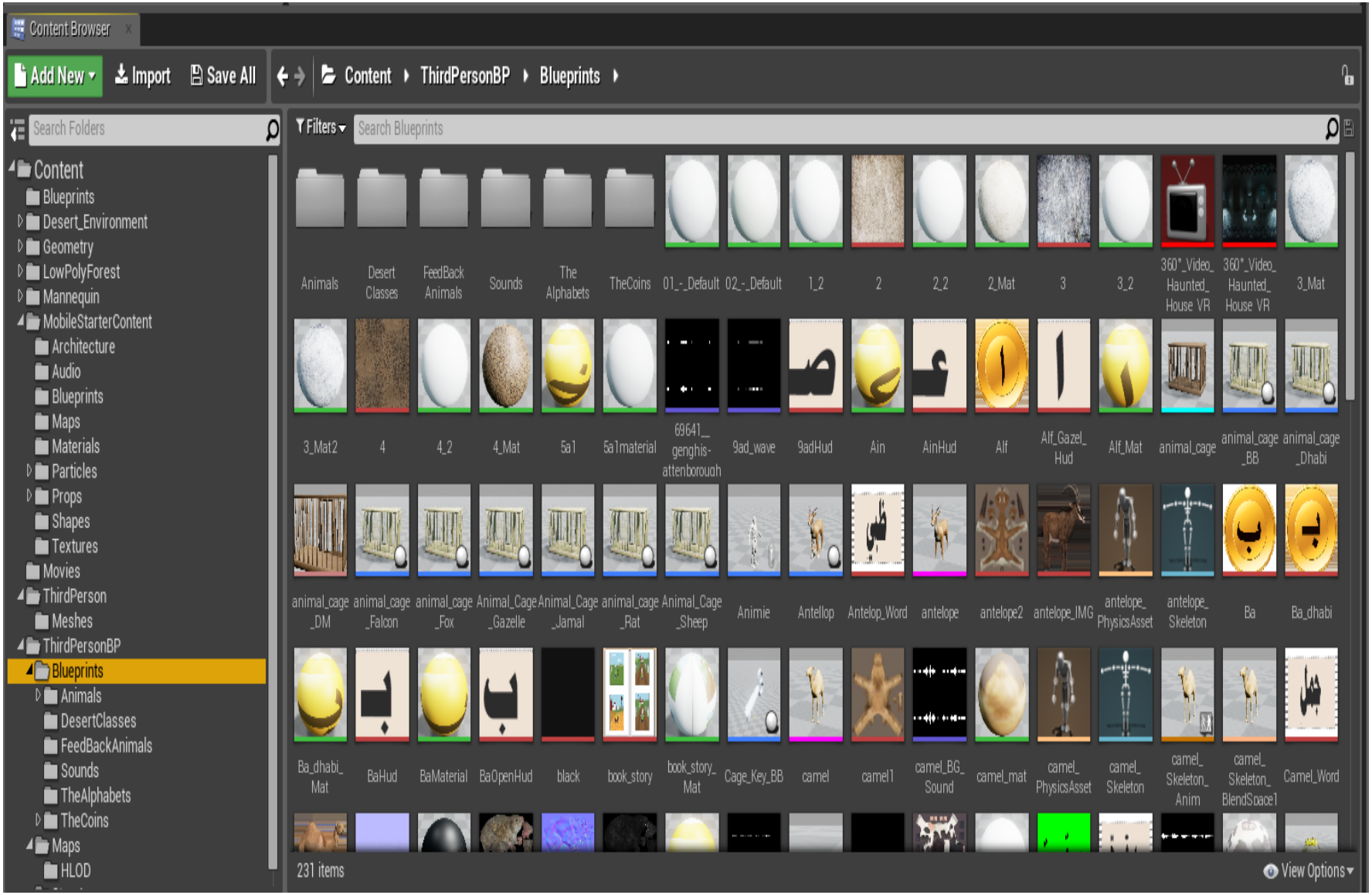


Figure B.2: Blueprints

Appendix C: Questionnaire

1. I forget about time passing while playing the game.
   - Not sure
   - Agree
   - Strongly agree

2. I become unaware of my surroundings while playing the game.
   - Not sure
   - Agree
   - Strongly agree

3. I experience an altered sense of time.
   - Not sure
   - Agree
   - Strongly agree

4. I temporarily forget worries about everyday life while playing the game.
   - Not sure
   - Agree
   - Strongly agree

5. I became involved in the game.
   - Not sure
   - Agree
   - Strongly agree

6. How easy is it to play the game?
   - hard
   - moderate
   - easy

7. Did you feel inside the game?
   - No
   - Yes

8. Was the game environment familiar?
   - not familiar
   - somewhat familiar

Figure C.1: VR Adult Experiment Questionnaire Sample (1)

- familiar

9. Was the device comfortable?

   - not comfortable
   - somewhat comfortable
   - comfortable

10. Were the words and pictures introduced in the game suitable for a 4-year child?

    - unsuitable
    - OK
    - Suitable

11. Using this game, I can easily interact with the 3D objects and elements

    - Not sure
    - Agree
    - Strongly agree

12. I have developed better understanding of the linguistic concepts

    - Yes
    - No

13. I have developed better understanding of the linguistic structures

    - Yes
    - No

14. I feel the 3D simulated environment provided by this system is realistic

    - Yes
    - No

15. I feel the 3D simulated environment makes me concentrate more while learning.

    - Yes
    - No

16. I'm willing to continue using this game in the future

    - Yes
    - No

Figure C.2: VR Adult Experiment Questionnaire Sample (2)

17. I think this system is worth to be a good learning tool

    - Sure
    - Not sure
    - Recommended

18. Please suggest ONE thing you would like to have in the game.

19. Do you have any comments on the graphics and the environments in general?

Figure C.3: VR Adult Experiment Questionnaire Sample (3)

References

[1] Eliot, L., *Early Intelligence: how the brain and mind develop in the first five years of life*. 2001.

[2] Adams, M. J., "Advancing our students' language and literacy: The challenge of complex texts.," *American Educator*, vol. 34, no. 4, p. 3, 2011.

[3] Hirsch, E. D., "Reading comprehension requires knowledge of words and the world," *American Educator*, vol. 27, no. 1, pp. 10–23, 2003.

[4] Pavlas, D., "A model of flow and play in game-based learning: The impact of game characteristics, player traits, and player states," 2010.

[5] Ertmer, P. A. and Newby, T. J., "Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective," *Performance improvement quarterly*, vol. 6, no. 4, pp. 50–72, 1993.

[6] Sarason, S. B., *And what do you mean by learning?* Heinemann Portsmouth, NH, 2004.

[7] De Houwer, J., Barnes-Holmes, D., and Moors, A., "What is learning? on the nature and merits of a functional definition of learning," *Psychonomic Bulletin & Review*, vol. 20, no. 4, pp. 631–642, 2013.

[8] Lenhart, A. and et al., "Teens, video games, and civics," tech. rep., Pew Internet & American Life Project, 2008.

[9] Anderson, J. and Rainie, L., "Gamification: Experts expect game layers to expand in the future, with positive and negative results," tech. rep., Pew Internet & American Life Project, 2012.

[10] Salen, K., *The Ecology of Games: Connecting Youth, Games, and Learning*, ch. Toward an Ecology of Gaming, pp. 1–20. Cambridge, MA: The MIT Press, 2008.

[11] Kirriemuir, J. and McFarlane, C., "Literature review in games and learning," tech. rep., Future Lab Series Report 8, 2012.

[12] NSF Task Force on Cyberlearning, "Fostering learning in the networked world: The cyberlearning opportunity and challenge," tech. rep., Pew Internet & American Life Project, 2008.

[13] Hwang, G.-J., "Definition, framework and research issues of smart learning environments-a context-aware ubiquitous learning perspective," *Smart Learning Environments*, vol. 1, no. 1, p. 1, 2014.

[14] Smith, L. and Mann, S., "Playing the game: A model for gameness in interactive game based learning," in *in Proceedings of the 15th annual NACCQ*, pp. 397–402, 2002.

[15] Furió, D., González-Gancedo, S., Juan, M.-C., Seguí, I., and Rando, N., "Evaluation of learning outcomes using an educational iphone game vs. traditional game," *Computers & Education*, vol. 64, pp. 1–23, 2013.

[16] C.-S.Wang, Liu, C.-C., , and Li, Y.-C., "A game-based learning content design framework for the elementary school children education, in nano, information technology and reliability (nasnit)," pp. 53–57, 2011.

[17] McClarty, K. L., Orr, A., Frey, P. M., R. P. Dolan, V. V., and McVay, A., "A literature review of gaming in education," *Gaming In Education*, 2012.

[18] Wouters, P., Van Nimwegen, C., Van Oostendorp, H., and Van Der Spek, E. D., "A meta-analysis of the cognitive and motivational effects of serious games.," *Journal of Educational Psychology*, vol. 105, no. 2, p. 249, 2013.

[19] Sitzmann, T., Kraiger, K., Stewart, D., and Wisher, R., "The comparative effectiveness of web-based and classroom instruction: A meta-analysis," *Personnel psychology*, vol. 59, no. 3, pp. 623–664, 2006.

[20] Ke, F., "A qualitative meta-analysis of computer games as learning tools," *Handbook of research on effective electronic gaming in education*, vol. 1, pp. 1–32, 2009.

[21] Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., and Boyle, J. M., "A systematic literature review of empirical evidence on computer games and serious games," *Computers & Education*, vol. 59, no. 2, pp. 661–686, 2012.

[22] Sitzmann, T., "A meta-analytic examination of the instructional effectiveness of computer-based simulation games," *Personnel psychology*, vol. 64, no. 2, pp. 489–528, 2011.

[23] Online, *Effect size*. https://en.wikipedia.org/wiki/Effect_size#Cohen.27s_d.

[24] Rasch, J. and Schnotz, W., "Interactive and non-interactive pictures in multimedia learning environments: Effects on learning outcomes and learning efficiency," *Learning and Instruction*, vol. 19, pp. 411–422, 2009.

[25] Toprac, P. and Abdel-Meguid, A., "Causing fear, suspense, and anxiety using sound design in computer games," *Game sound technology and player interaction: Concepts and developments*, pp. 176–191, 2010.

[26] Charsky, D., "From edutainment to serious games: A change in the use of game characteristics," *Games and culture*, 2010.

[27] Online, *Educational Games*. https://en.wikipedia.org/wiki/Educational_game.

[28] Shaffer, D. W., Halverson, R., Squire, K. R., and Gee, J. P., "Video games and the future of learning. wcer working paper no. 2005-4," *Wisconsin Center for Education Research (NJ1)*, 2005.

[29] Baker, D., Prince, C., Shrestha, L., Oser, R., and Salas, E., "Aviation computer games for crew resource management training," *The International Journal of Aviation Psychology*, vol. 3, no. 2, pp. 143–156, 1993.

[30] Gopher, D., Weil, M., Bareket, T., and Caspi, S., "Using complex computer games as task simulators in the training of flight skills," in *Systems, Man, and Cybernetics, 1988. Proceedings of the 1988 IEEE International Conference on*, vol. 2, pp. 938–941, IEEE, 1988.

[31] Clark, J. M. and Paivio, A., "Dual coding theory and education," *Educational psychology review*, vol. 3, no. 3, pp. 149–210, 1991.

[32] Al Mazrouei, S. A., Al Derei, N., and Belkhouche, B., "A game-based learning software model. in innovations in information technology (iit), 2015 11th international conference," pp. 350–355, 2015.

[33] Dede, C., "Immersive interfaces for engagement and learning," *science*, vol. 323, no. 5910, pp. 66–69, 2009.

[34] McMahan, A., "Immersion, engagement and presence," *The video game theory reader*, vol. 67, p. 86, 2003.

[35] Nakamura, J. and Csikszentmihalyi, M., "The concept of flow," in *Flow and the foundations of positive psychology*, pp. 239–263, Springer, 2014.

[36] Bedwell, W. L., Pavlas, D., Heyne, K., Lazzara, E. H., and Salas, E., "Toward a taxonomy linking game attributes to learning: An empirical study," *Simulation & Gaming*, vol. 43, no. 6, pp. 729–760, 2012.

[37] Dickey, M. D., "Engaging by design: How engagement strategies in popular computer and video games can inform instructional design," *Educational Technology Research and Development*, vol. 53, no. 2, pp. 67–83, 2005.

[38] de Freitas, S. and Campos, P., "SMART: a SysteM of Augmented Reality for Teaching 2nd grade students," in *22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction (September*, pp. 27–30, British Computer Society, 2008.

[39] Mathiak, K. and Weber, R., "Toward brain correlates of natural behavior: fmri during violent video games," *Human brain mapping*, vol. 27, no. 12, pp. 948–956, 2006.

[40] Mueller, C., Luehrs, M., Baecke, S., Adolf, D., R, L., Luchtmann, M., and Bernarding, J., "Building virtual reality fmri paradigms: a framework for presenting immersive virtual environments," *Neuroscience Methods*, vol. 209, no. 2, pp. 290–298, 2012.

[41] Dunwell, I., Lameras, P., Petridis, P., Arnab, S., and De Freitas, S., "Facilitating intuitive-guided learning in a serious game through integration with a learning content manage-

ment system," in *Complex, Intelligent and Software Intensive Systems (CISIS), 2014 Eighth International Conference on*, pp. 265–272, IEEE, 2014.

[42] Kiili, K., "Digital game-based learning: Towards an experiential gaming model," *The Internet and higher education*, vol. 8, no. 1, pp. 13–24, 2005.

[43] Berns, A., Gonzalez-Pardo, A., and Camacho, D., "Game-like language learning in 3-d virtual environments," *Computers & Education*, vol. 60, no. 1, pp. 210–220, 2013.

[44] Ermi, L. and Mäyrä, F., "Fundamental components of the gameplay experience: Analysing immersion," *Worlds in play: International perspectives on digital games research*, vol. 37, no. 2, 2005.

[45] Kiili, K., de Freitas, S., Arnab, S., and Lainema, T., "The design principles for flow experience in educational games," *Procedia Computer Science*, vol. 37, no. 15, pp. 78–91, 2012.

[46] Cowley, B., Charles, D., Black, M., and Hickey, R., "User-system-experience model for user centered design in computer games," in *International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems*, pp. 419–424, Springer, 2006.

[47] Orvis, K., Horn, D., and Belanich, J., "Videogame-based training success: The impact of trainee characteristics-year 2 (technical report, no. 1188)," *Arlington, VA: US Army Research Institute for the Behavioral and Social Sciences*, 2006.

[48] Wilson, K. A., Bedwell, W. L., Lazzara, E. H., Salas, E., Burke, C. S., Estock, J. L., Orvis, K. L., and Conkey, C., "Relationships between game attributes and learning outcomes review and research proposals," *Simulation & gaming*, vol. 40, no. 2, pp. 217–266, 2009.

[49] Ermi, L. and Mäyrä, F., "Fundamental components of the gameplay experience: Analysing immersion," *Worlds in play: International perspectives on digital games research*, vol. 37, p. 2, 2005.

[50] Sherman, W. R. and Craig, A. B., *Understanding virtual reality: Interface, application, and design*. Elsevier, 2002.

[51] Huang, H.-M., Rauch, U., and Liaw, S.-S., "Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach," *Computers & Education*, vol. 55, no. 3, pp. 1171–1182, 2010.

[52] Pavlas, D., *A model of flow and play in game-based learning: The impact of game characteristics, player traits, and player states*. PhD dissertation, University of Central Florida Orlando, Florida, 2010.

[53] Yang, J. C., Chen, C. H., and Jeng, M. C., "Integrating video-capture virtual reality technology into a physically interactive learning environment for english learning," *Computers & Education*, vol. 55, no. 3, pp. 1346–1356, 2010.

[54] Moreno, R. and Mayer, R. E., "Virtual reality and learning: Cognitive and motivational effects of students' sense of presence," *Human-Computer Interaction Proceedings*, pp. 65–67, 2001.

[55] Bell, J. T. and Fogler, H. S., "The investigation and application of virtual reality as an educational tool," in *Proceedings of the American Society for Engineering Education Annual Conference*, pp. 1718–1728, 1995.

[56] Shih, Y.-C. and Yang, M.-T., "A collaborative virtual environment for situated language learning using vec3d.," *Educational Technology & Society*, vol. 11, no. 1, pp. 56–68, 2008.

[57] Malone, T. W., "What makes things fun to learn? heuristics for designing instructional computer games," in *Proceedings of the 3rd ACM SIGSMALL symposium and the first SIGPC symposium on Small systems*, pp. 162–169, ACM, 1980.

[58] Pintrich, P. R. and De Groot, E. V., "Motivational and self-regulated learning components of classroom academic performance.," *Journal of educational psychology*, vol. 82, no. 1, p. 33, 1990.

[59] Payne, S. C., Youngcourt, S. S., and Beaubien, J. M., "A meta-analytic examination of the goal orientation nomological net.," *Journal of Applied Psychology*, vol. 92, no. 1, p. 128, 2007.

[60] Webster, J. and Martocchio, J. J., "Microcomputer playfulness: development of a measure with workplace implications," *MIS quarterly*, pp. 201–226, 1992.

[61] McClarty, K. L., Orr, A., Frey, P. M., Dolan, R. P., Vassileva, V., and McVay, A., "A literature review of gaming in education," *Gaming in education*, 2012.

[62] Rieber, L. P., "Multimedia learning in games, simulations, and microworlds," *The Cambridge handbook of multimedia learning*, pp. 549–567, 2005.

[63] Sherman, W. R. and Craig, A. B., *Understanding virtual reality: Interface, application, and design*. Elsevier, 2002.

[64] Slater, M. and Wilbur, S., "A framework for immersive virtual environments (five): Speculations on the role of presence in virtual environments," *Presence: Teleoperators and virtual environments*, vol. 6, no. 6, pp. 603–616, 1997.

[65] Grimshaw, M., "Sound and immersion in the first-person shooter," *International Journal of Intelligent Games and Simulation*, vol. 5, no. 1, pp. 119–124, 2008. this paper is about NOTHING.

[66] Jones, M. G., "Creating electronic learning environments: Games, flow, and the user interface.," 1998.

[67] Pavlas, D., Bedwell, W., Wooten, S. R., Heyne, K., and Salas, E., "Investigating the attributes in serious games that contribute to learning," in *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 53, pp. 1999–2003, SAGE Publications, 2009.

[68] Sweetser, P. and Wyeth, P., "Gameflow: a model for evaluating player enjoyment in games," *Computers in Entertainment (CIE)*, vol. 3, no. 3, pp. 3–3, 2005.

[69] Chen, J., "Flow in games (and everything else)," *Communications of the ACM*, vol. 50, no. 4, pp. 31–34, 2007.

[70] Adams, E., *Fundamentals of game design*. Pearson Education, 2014.

[71] Pavlas, D., Heyne, K., Bedwell, W., Lazzara, E., and Salas, E., "Game-based learning: The impact of flow state and videogame self-efficacy," in *Proceedings of the human factors and ergonomics society annual meeting*, vol. 54, pp. 2398–2402, SAGE Publications, 2010.

[72] O'Connor, J. S. and LaPoint, J. D., "The phenomenon of play: A multi-dimensional definition," *RSJ*, vol. 5, no. 1, 2010.

[73] Slater, M., Linakis, V., Usoh, M., Kooper, R., and Street, G., "Immersion, presence, and performance in virtual environments: An experiment with tri-dimensional chess," in *ACM virtual reality software and technology (VRST)*, pp. 163–172, ACM Press New York, NY, 1996.

[74] Baños, R. M., Botella, C., Alcañiz, M., Liaño, V., Guerrero, B., and Rey, B., "Immersion and emotion: their impact on the sense of presence," *CyberPsychology & Behavior*, vol. 7, no. 6, pp. 734–741, 2004.

[75] Barfield, W., Zeltzer, D., Sheridan, T., and Slater, M., "Presence and performance within virtual environments," *Virtual environments and advanced interface design*, pp. 473–513, 1995.

[76] Riva, G., Davide, F., and IJsselsteijn, W., "Being there: The experience of presence in mediated environments," *Being there: Concepts, effects and measurements of user presence in synthetic environments*, pp. 3–16, 2003.

[77] IJsselsteijn, W. A., de Ridder, H., Freeman, J., and Avons, S. E., "Presence: concept, determinants, and measurement," in *Electronic Imaging*, pp. 520–529, International Society for Optics and Photonics, 2000.

[78] Kalawsky, R. S., "The validity of presence as a reliable human performance metric in immersive environments," in *proceedings of the Presence Workshop'00*, 2000.

[79] Lessiter, J., Freeman, J., Keogh, E., and Davidoff, J., "A cross-media presence questionnaire: The itc-sense of presence inventory," *Presence*, vol. 10, no. 3, pp. 282–297, 2001.

[80] Lombard, M. and Ditton, T., "At the heart of it all: The concept of presence," *Journal of Computer-Mediated Communication*, vol. 3, no. 2, pp. 0–0, 1997.

[81] Al Mazrouei, S. A., Al Derei, N. S., and Belkhouche, B., "A game-based learning software model," in *Innovations in Information Technology (IIT), 2015 11th International Conference on*, pp. 350–355, IEEE, 2015.

[82] Wouters, P., van Nimwegen, C., van Oostendorp, H., and van der Spek, E., "A meta-analysis of the cognitive and motivational effects of serious games," in *Educational Psychology*, p. 249, 2013.

[83] Wang, T.-L. and Tseng, Y. F., "Learning effect for students with game-based learning on meta-analysis," in *in Computer Science & Education (ICCSE), 2011 6th International Conference on. IEEE*, pp. 1291–1295, IEEE, 2011.

[84] Ramsi, F. A. M., "A game-based learning model," 2015.

[85] Vygotsky, L., *Mind in society.(M. Cole, Trans.)*. Cambridge, MA: Harvard University Press, 1978.

[86] Marczewski, A., "Game mechanics in gamification," *Web log post. Gamasutra. Np*, vol. 6, 2013.

[87] Razumnyy, I., "Designing an educational game for mobile learning environments," 2005.