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ΠΟΛΥΤΕΧΝΙΚΗ ΣΧΟΛΗ

ΤΜΗΜΑ ΗΛΕΚΤΡΟΛΟΓΩΝ ΜΗΧΑΝΙΚΩΝ & ΤΕΧΝΟΛΟΓΙΑΣ ΥΠΟΛΟΓΙΣΤΩΝ

Σχεδιασμός και Ανάπτυξη Ψηφιακού Παιχνιδιού Μάθησης

Design and Development of Digital Learning Game

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Ο Διευθυντής του Τομέα

ΠΟΛΥΤΕΧΝΙΚΗ ΣΧΟΛΗ
ΤΜΗΜΑ ΗΛΕΚΤΡΟΛΟΓΩΝ ΜΗΧΑΝΙΚΩΝ & ΤΕΧΝΟΛΟΓΙΑΣ ΥΠΟΛΟΓΙΣΤΩΝ

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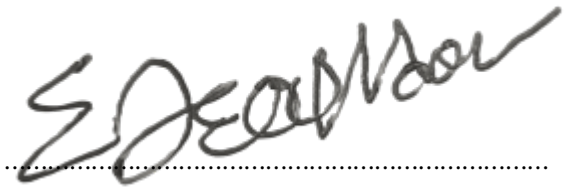

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Θεοφίλου Στυλιανός

Σύνοψη

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Λέξεις-κλειδιά: Κβαντική Υπολογιστική, Κβαντική Μηχανική, Παιχνίδι για κινητά, Εφαμρογή για κινητά, Flutter

Abstract

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Keywords: Quantum Computing, Quantum Mechanics, Mobile Game, Mobile App, Flutter

Ευχαριστίες

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Περιεχόμενα

Κατάλογος πινάκων

Κατάλογος σχημάτων

1 1 Introduction

1.1 Motivation

Quantum computers can solve complex problems in a minimum of time using a few quantum bits, while classical computers would take longer than the timescale of human civilization or require billions of classical bits and very expensive hardware.

The development and widespread use of quantum computing can help in fields such as pharmaceuticals, cryptography, artificial intelligence, materials science and more. Since quantum computing represents a new era for computer science, opening up new prospects for accelerating scientific discoveries, learning the basic principles of quantum computing is extremely important.

1.2 What is Game-Based Learning

https://decodoku.medium.com/why-we-need-to-make-quantum-games-6f8c7bc4ace7 https://elearningindustry.com/7-tips-game-based-learning https://www.gamedesigning.org/learn/game-based-learning/ https://bedrocklearning.org/literacy-blogs/the-pros-and-cons-of-game-based-learning/

Game-based learning is a very old practice; it did not start with the advance of modern technology. It can be defined as the technique of being educated by playing games. It integrates the characteristics and principles of games such as elements of competition, rewards and active user engagement, into learning activities. Games can be an interactive tool that can simplify challenging concepts and help learners understand complex ideas, engaging them into educational content.

1.3 Benefits of Game Based Learning

https://bedrocklearning.org/literacy-blogs/the-pros-and-cons-of-game-based-learning/ https://www.gamedesigning.org/learn/game-based-learning/

First, game-based learning is more appealing to children, as it appears to be a game on the surface, but in the background it has the ability to stimulate children’ s curiosity and capture their imagination.

It is a friendlier and more accessible mean of engaging young learners with a subject than traditional methods, as it is fun and motivating.

Game-based learning also has the ability to enhance critical thinking and problem-solving, as they involve human instinct to compete and desire to succeed. Because learners often compete with other players, they have to collaborate and share ideas. They must listen to and evaluate the opinions of other players and take into account the tactics of opposing teams.

Games often require users to react quicker to stimuli, make critical decisions in a short period of time and combine knowledge acquired during the game to solve complex problems. Due to their repetitive and interactive nature, they have the ability to improve retention and increase the brain' s capacity to memorize things.

Also, as games are flexible, they can be adapted to different learning styles, levels and paces, meeting individual needs and can also give instant feedback about where gaps in knowledge are or provide specific tasks for the user to help cover these areas. In this way, they can further help learners to identify their strengths and weaknesses.

Comparing games to traditional textbooks, although the latter have been used for many years with success, their revision and renewal takes a long time and is difficult and costly. The cost of reprinting, redistributing and recycling or storing old textbooks must be taken into account. Even in the case of digital textbooks, there is a significant cost of disposal and renewal. By contrast, games are very versatile, their rules can be adapted easily, and their content can be changed quickly to keep pace with technological and scientific progress.

In summary, game-based learning offers a modern, engaging and flexible approach to education. It is a great way to improve learners' critical thinking and problem-solving skills, boost their creativity and keep them engaged and motivated. Also, unlike traditional textbooks, it can be quickly and cost-effectively updated, in order to reflect new information and technological progress.

1.4 Research Objectives

The aim of this thesis is to familiarize the learners with the basic principles of quantum computing, such as quantum bits and quantum gates. They should not be distracted or get tired due to the complexity of the game. The aim is to design a simple and accessible educational game, with few rules and clear objectives.

In order to play this educational game, one does not need to have a university background in mathematics or a strong background in quantum physics. The game can be played by anyone who is interested in learning how quantum gates work and how they affect quantum bits.

In addition, it is desirable that the game could be played at any time and in any place, without the need of equipment or a computer. The aim is that the user can play even when he has limited time (e.g. travelling, waiting for public transportation, etc.), and for the game to be suitable for playing in a class, in the context of a lecture.

For these reasons, a classic digital game, for mobile devices, with simple mechanisms and low complexity should be chosen, whose rules and objectives should be adapted to the topic of quantum computing.

1.5 Thesis Structure

2 Literature Review

2.1 Computer Science Games for Higher Education

https://www.researchgate.net/publication/325046233_Games_for_Teaching_Computing_in_Higher_Education_-_A_Systematic_Review

2.2 Quantum Physics Games

2.2.1 Desktop and Web Games

:memo: **Name**: Name of the game :memo: **Created By**: Name of the creator (university or institution or student or individual) e.g. Student at University of Aalto :memo: **URL**: Where the game is hosted :memo: **Educational**: Was the game designed for educational purposes? True/False :memo: **Competition**: Was the game created for a competition? True/False :memo: **Course**: Was the game created in the scope of a course? True/False :memo: **Platform**: Desktop or Web

List Of Quantum Games

1) Finnish Game Jam

   - Competition for game developers.
   - Desktop games: User must download the source files and build the game.
   - Browser games.
   - Most of the games are available on itch.io:
   - Games created by Finnish Game Jam are not designed for educational purposes.
   - The target of this competition is to create games with limited time and resources but with unlimited creativity [link].

2) QPlayLearn

   - Platform with web-based educational games.
   - Uses interactive tools to make the learning process more effective and entertaining for different target groups [link].

3) Quantum Games Course by Aalto University

   - Course offered by Aalto University
   - Games are not designed for educational purposes.
   - This course is designed to teach students how to design and develop games and also learn the basic concepts of quantum computing.

4) Science At Home

   - Aarhus University
   - Browser and desktop educational games
   - Diverse team of scientists, designers and game developers that create scientific games, aiming at teaching by game-play [link]

5) github / gitlab

   - Lots of desktop games. Most of them use Jupyter Notebooks.
   - The majority of these games are not designed for educational purposes. They have been developed in the context of competitions or workshops.

6) Decodoku

   - Has created a lot of quantum games. The games are hosted on itch.io.
   - The games does not have an educational purpose.
   - Most of them are designed to run on the IBM Quantum Platform
   - Browser and desktop games

Conclusions: - Educational or not? - Quantum Computing or Particle Physics? - Designed by professionals, universities or just for fun? - Desktop or web? - Programming language - Technologies? Consider adding table

2.2.2 Mobile Games

2.2.2.1 Google Play Store (for android devices)

- Quantum
  - Educational app
  - 13 chapters
  - 4 tests - 60 different questions
- QuantumQ
  - Puzzle game with theory

  - Quantum gates and quantum circuits

- Learn Quantum Physics
  - Educational app
  - Designed for students and professionals
- Quantum Computing
  - Educational app
- Quantum 3:
  - Educational game designed by Michigan State University
  - Puzzle game
  - Particle physics

2.2.2.2 App Store (for iOS devices)

- Quantum Mechanics
  - Educational app
  - Particle physics
- Qika Quantum Game: Qika is a quantum game which you need to apply quantum gates to qubits in the grid. You need to change the states of qubits by applying gates in order to reach the target measurement.
  - Puzzle game
  - Applying quantum gates to qubits on order to reach a target measurement !!! Basic concept of our game !!!
- Quantum 3:
  - Same as android game
  - Educational game designed by Michigan State University
  - Puzzle game
  - Particle physics
- Quantum Kate AR:
  - Educational game
  - Casual -> Simulation -> Adventure game
  - Particle physics

Conclusions: - Educational or not? - Quantum Computing or Particle Physics? - Designed by professional, Universities or just for fun? - Android or iOS? - Programming language - Technologies? Consider adding table

2.3 Why a mobile game?

https://www.ncfe.org.uk/all-articles/how-educational-games-are-changing-the-way-we-learn/

https://www.researchgate.net/figure/Core-educational-value-of-mobile-games_fig5_360277617

https://www.linkedin.com/pulse/top-7-reasons-using-mobile-apps-education-e-learning-industry-ved-raj

2.4 Mobile Games Development Technologies

Short description of the technologies.

web based (js) OR android based (?) OR iOS based (consider also developing 3 separate apps for web/android/iOS?) cross-platform game: Use a cross-platform framework like flutter or react-native

2.5 Why Flutter?

Why we selected flutter? - cross-platform: Υπήρχαν πιο πολλές εφαρμογές android. Εμείς θέλουμε όλοι οι χρήστες να μπορούν να παίξουν, ανεξάρτητα από τη συσκευή που έχουν. - Άλλα πλεονεκτήματα flutter π.χ. απόδοση/ταχύτητα σε σχέση με τις άλλες επιλογές??? - Επιπλέον της υποστήριξης από android και iOS, η εφαρμογή μπορεί εύκολα να διατεθεί και ως desktop ή web app. - Βιβλιοθήκες για κβαντικούς υπολογισμούς (συμβατές με το Dart version 3) * https://pub.dev/packages/qartvm * https://pub.dev/packages/quantools - Βιβλιοθήκες για πίνακες * https://api.flutter.dev/flutter/vector_math/vector_math-library.html * https://pub.dev/packages/advance_math (supports complex numbers and matrices)

3 Mobile Game Categories, Genres and Subgenres

https://docs.gamerefinery.com/en/collections/112330-game-categories-genres-subgenres https://docs.gamerefinery.com
what-are-categories-genres-and-subgenres

Gamerefinery [2278730] has developed a flexible three-layer classification that allows mobile games to be easily grouped under distinctive genres. Each game is classified into a subgenre, according to its features and mechanics. This subgenre belongs to one genre, which in turn belongs to one category. This three-layered approach acts as a helpful taxonomy for market and game research, as it provides game developers a singular unified approach to categorizing games.

Εικόνα 3.1. Game Categories, Genres and Subgenres according to GameRefinery

There are 4 categories, Casino games, Sports, Mid-core and Casual games. Each category has genres, which will be described in detail below. At the genre level, the differences between the games begin to become apparent. At the third level, the subgenre level, the mechanisms of the games become distinct.

3.1 Category #1: Casino

The casino category contains only one genre, the casino genre.

3.1.1 Genre #1.1: Casino

This genre contains traditional casino and gambling games. It has five subgenres.

3.1.1.1 Bingo

Games about playing bingo with others are included in this subgenre.

3.1.1.2 Cards

Includes casino card games, such as poker or blackjack.

3.1.1.3 Slots

This subgenre includes casino games with slot machines.

3.1.1.4 Casual Casino

Includes games that combine gambling elements with casual gameplay. For example, a game may have a casual casino-style gameplay (e.g. using slot machines) along with elements such as town building.

3.1.1.5 Other

Casino games that cannot be part of the categories above.

3.2 Category #2: Casual Games

This category contains six genres.

3.2.1 Genre #2.1: Hyper Casual

These games have very simple controls and are easy to learn. They are designed for short playing sessions and are very straightforward. They are divided into six subgenres.

3.2.1.1 Puzzle

Games where you have to solve some kind of puzzles.

3.2.1.2 Tap

These games require timing and precise and fast reactions. The gameplay focuses on tapping or holding one or more fingers on the device' s screen at the right time.

3.2.1.3 Steer

Includes games that require timing and reaction and the gameplay focuses on steering an object either by tilting the device or with some fingers.

3.2.1.4 Swipe / Drag

The gameplay focuses on swiping fingers or dragging and releasing objects.

3.2.1.5 IO

The main idea behind these games is for the player to grow by destroying other players or bots smaller than him and ultimately become the king of the whole gameplay area.

3.2.1.6 Other

Includes hyper casual games that don' t belong to any of the subgenres described above.

3.2.2 Genre #2.2: AR / Location Based

These games utilize augmented reality elements and location technology. This category does not have subgenres.

3.2.3 Genre #2.3: Arcade

These games have straightforward controls and mechanics for short and casual playing sessions.

3.2.3.1 Platformer

Casual platformer jumper games, where the player has to get through stages by jumping, running or gliding, while avoiding obstacles and/or enemies.

3.2.3.2 Shoot Them Up / Beat Them Up

Includes arcade style shooting and fighting games, with simple controls and lots of action, with no real emphasis on precise aiming or tactics.

3.2.3.3 Tower Defense

These games use tower defense mechanics. Main goal of the players is to prevent the enemies from reaching a certain point or target on the screen. Usually the enemies come in waves of increasing difficulty.

3.2.3.4 Board Games

Includes classic board game titles, either direct conversions of traditional board games to mobile versions, or games that utilize board games mechanics.

3.2.3.5 Other

Arcade games that do not fit in any other subgenre.

3.2.4 Genre #2.4: Lifestyle

These are games that revolve around lifestyle themes, such as decorating, fashion or customizing the look and style of models.

3.2.4.1 Customization

This subgenre includes games that focus on customizing or designing things, such as wardrobes or rooms.

3.2.4.2 Interactive Story

These games have very light mechanics and emphasize on interactive storytelling. Players' decisions affect the progress of the story.

3.2.4.3 Music / Band

Includes games where music and rhythm are affecting theme and mechanics. There are many customization options regarding style and look.

3.2.5 Genre #2.5: Simulation

These are casual games focusing on constructing and developing farms, cities, worlds or entities, while completing several tasks and side quests to progress in the game.

3.2.5.1 Adventures

In these games, players are focusing on completing tasks and collecting various items in order to process. The mechanics are often pretty lightweight, as they are limited to tapping or dragging objects. Emphasis is placed on the story and collecting aspects.

3.2.5.2 Breeding

Includes games that revolve around breeding creatures with each other, in order to get new, better creatures (e.g. breed two dragons to get a stronger dragon)

3.2.5.3 Tycoon / Crafting

The mechanics of these games revolve around construction and resource management.

3.2.5.4 Sandbox

The players of these games are free to roam the world of the game. They can craft things that will help them survive or grow. Emphasis is placed on user-generated content.

3.2.5.5 Time Management

Includes games where the players have to complete various tasks quickly, accurately and in the right order.

3.2.5.6 Idler

'Idler mechanics' means that the game plays itself even if the application is closed. When the application is open, players can see progress happening all the time - even if they are not doing anything themselves (e.g. crops growing, money or energy keeps generating etc.).

3.2.6 Genre #2.6: Puzzle

These games are focusing on puzzle solving or trivia and often use traditional board game mechanics.

3.2.6.1 Match-Three Puzzle

In these games players have to match pieces together to clear them from the board.

3.2.6.2 Bubble Shooter

They are Match-Three puzzles where you shoot board pieces -instead of swapping them- to make matches and clear the board.

3.2.6.3 Merge Games

Includes games where the players have to combine similar objects to create new objects of a higher tier. Merging is used to clear boards or upgrade items.

3.2.6.4 Action Puzzle

This subgenre includes games that require speed, aiming or directing an object in order to solve puzzles.

3.2.6.5 Word Games

These are games where the players have to solve word puzzles, like constructing or guessing words from given letters.

3.2.6.6 Trivia

Includes games that test players' general knowledge by asking questions. They often consist of levels of increasing difficulty.

3.2.6.7 Coloring Games

These games use tap-to-color or swipe-to-color mechanics, allowing players to experience a digital version of a coloring book.

3.2.6.8 Hidden Objects

Games that revolve around finding and tapping hidden objects in static scenes to progress in the game.

3.2.6.9 Solitaire

Includes solitaire games, as well as Mahjong Solitaire.

3.2.6.10 Other

Games focused on puzzle solving that do not belong to any of the subgenres described above.

3.3 Category #3: Mid-Core

3.3.1 Genre #3.1: Shooter

3.3.2 Genre #3.2: Card Games

3.3.3 Genre #3.3: Role Playing Games (RPG)

3.3.4 Genre #3.4: Strategy

3.4 Category #4: Sports and Driving

3.4.1 Genre #4.1: Sports

3.4.2 Genre #4.2: Driving

4 Bibliography