Using 3D Graphics and Interfaces in Training Games

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Abstract. This paper is devoted to the use of computer three-dimensional graphics and interface for developing educational games that contribute to the gamification of the training process. Similar educational games-analogues are considered, which were created by modern scientists and specialists, in order to fill the games with high-quality content for training. There is given a brief description of the software that is used in the development of game logic and building levels and interfaces that is Unity game engine.
In addition to theoretical data, the paper describes the process of developing a graphical three-dimensional environment of the game, from the point of view of the psychology of perception, color, shapes and space, and the user interface, from the point of view of psychological techniques, usability and visual design. The analysis of the interaction between the game and the student was the key point discussed in this paper: how the student can learn about the virtual world and interact with it during the game is an important point that affects the creation of the user interface and game levels.
After the development of the game was completed, it was implemented, followed by a survey of a group of students who completed testing at the end of the game. The paper final part gives brief description of the results and provides a comparative table of findings compiled according to game implementation and testing of students.

1. Introduction

Interface design is associated with a wide range of projects, from computer systems to cars and airplanes. They all relate to the same basics of human interaction, but require some unique skills and knowledge. There are various disciplines related to the development of graphical user interfaces:

1. UX design. UX design focuses on the sequence of actions that occur with users while working with the product and ensures that the user will achieve his goals and will be satisfied.

2. Interaction design (IxD). Interaction design (IxD) focuses more on user behavior. The word "interaction" refers to the design subject: interaction with digital products, systems, or services.

3. Usability. Usability evaluates how easy it is to learn and use the product.

4. Visual design. Visual design defines “appearance" of the product. Visual design works with colors, typography, icons, animation, and the overall aesthetics of the final product.

All these areas are popular at the moment and have a huge number of specialists in their field.

The user interface is a space where human-machine interaction takes place. The aim of this interaction is to ensure that the machine functions effectively and is controlled by the person, while the machine simultaneously feeds back information that helps the person make decisions. This paper considers the relationship between a student and a training game that uses 3D computer graphics

technologies, as well as the creation of the game user interface, not only related to the design, but also to usability, UX, IxD, and visual design.

Aims of GUI development:

1. Creating a clear and simple game interface
2. Using 3D graphics to create a game environment
3. Analysis of the interface interaction between the player and the game
4. Development of the visual design suitable for gamification of training process

Tasks:

1. Study game analogues and their implementation of the user interface (UI)
2. Develop the mechanics of user interaction with the interface, as well as ways to explore the surrounding game world.
3. Design a user-friendly interface that is suitable for training.
4. Develop a visual design for filling the interface elements.

The use of three-dimensional graphics for developing computer educational games is not an innovation. Starting with simple puzzles for kids and ending with serious simulations for pilots and astronauts, the use of three-dimensional space, which better reflects the real world than 2D, allows players to immerse themselves in the world and mechanics of the game better, increases their involvement in the gameplay and also improves the quality of the experience obtained during the game.

There are plenty of examples of games that use the three-dimensional world as an educational and exciting space for players. One of these games is Beyond Blue, released in 2020 (Fig. 1). This is a single-player game in the style of an adventure story, in which the player is transported to the near future and learns the secrets of the ocean, viewing the underwater world through the eyes of Mirai, a scientist and researcher of the ocean depths. Together with her, a research team armed with innovative technologies will study the ocean through observation, listening, and interaction. An interesting key fact when creating this game was to attract really existing ocean scientists, interviews and documentary frames which the player can see in the game.

Another equally amazing example is Never Alone, a 3D puzzle platformer developed in collaboration with native Alaskan Iñupiaq people, and based on the traditional story passed down through generations.

The player acts as a girl and an Arctic fox, paving their way through the dangerous expanses of the Arctic, from tundra and coastal villages to ice floes and mysterious forests, icy tundra, treacherous ice floes and underwater caves, and fighting both known and unknown enemies. To make the game Never Alone authentic, it was created by the elders and storytellers of the native Alaskan people. In the game, you can also listen to the story of Kunuuksayuka performed by a storyteller from the Iñupiaq tribe in their native language, something that has not yet been seen in any video game and also unlock, as the story progresses, special video courses recorded by the Iñupiaq community to allow players to touch their traditions, wisdom and life views.

2. Theoretical part

2.1. Review of the game engine used

In general, to create these and other games studios use either their own developed game engine, or use ready-made ones that are freely available or available by subscription.

A game engine is the basic software of a computer game that can be reused and expanded, and thus can be considered as the basis for developing many different games without significant changes. As a rule, the game engine provides a lot of functions that allows them to be used in various games, which include modeling physical environments, normal maps, dynamic shadows, and much more. The implementation of 3D technologies in various engines can be different - the use of different methods for displaying objects on the screen, light and its optics, texture generation, and much more.

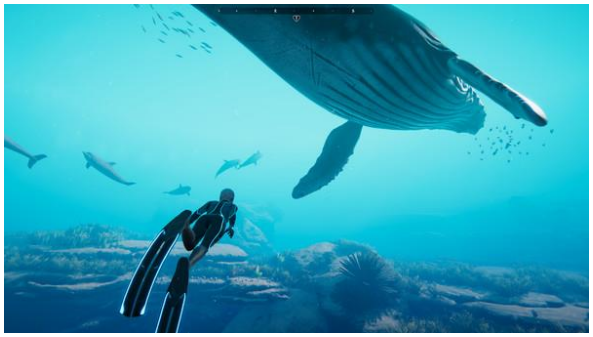

Figure 1. Frames from Beyond Blue game.

Choosing a game engine for a project is, without any doubt, an extremely important and determinative procedure, which must be treated very responsibly. Proper preparation for this choice will help you correctly determine the requirements when creating a game and choose the most appropriate software product to meet them. For example, one engine is more suitable for mobile development, because its ready-made projects use less memory, and others for large AAA projects, where high refinment and drawing is required.

Let us analyze the selected game engine for further development, which is studied in this paper, that is Unity.

Unity is a cross-platform computer game development environment created by the American company Unity Technologies. Unity allows to create applications that run on more than 25 different platforms, including personal computers, game consoles, mobile devices, Internet applications, and others. Unity was released in 2005 and has been continuously developed since then.

The main advantages of Unity are the availability of a visual development environment (Fig. 2), cross-platform support, and a modular component system. Disadvantages include the appearance of difficulties when working with multicomponent schemes and difficulties when connecting external libraries.

Thousands of games, applications, and mathematical model visualizations have been made on Unity, covering a variety of platforms and genres. At the same time, Unity is used by both large developers and independent studios.

Unlike many game engines, Unity has two main advantages: a visual development environment and cross-platform support. The first factor includes not only visual modeling tools, but also an integrated environment, the build chain, which is aimed at improving the productivity of developers, in particular, the stages of prototyping and testing.

The third advantage is the modular system of Unity components, which is used to construct game objects, when the latter are combined packages of functional elements. Unlike inheritance mechanisms, objects in Unity are created by combining functional blocks, rather than being placed in nodes of the inheritance tree. This approach makes it easier to create prototypes, which is important when developing games.

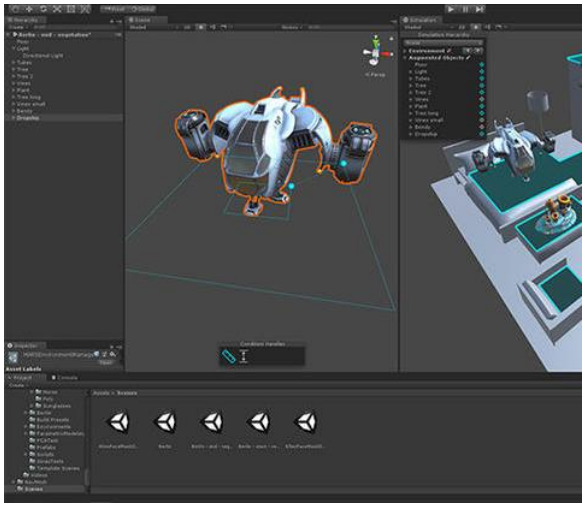

Figure 2. Interface of Unity engine.

2.2. Development of the game environment by means of perceptual psychology

Knowing the features of human perception allows to manipulate the emotional mood of the player. Psychological impact is usually achieved through the correct selection of colors, shapes, light, and a combination of different spaces. This approach makes it possible to maximize the effect of immersion, as well as to create many impressive and memorable moments.

Next, we will consider the features of human perception of the game environment and ways to form the necessary emotional mood of the player, using the example of the created game environment.

2.3. Perception of details

As a rule, most players immediately pay attention to the quality of working out small details at the very beginning of the game. The first value judgment about the level of details is made by the player during the first 15-20 minutes of his being in the virtual world. Therefore, the initial or starting levels should be as detailed and impressive as possible.

The first impression is important, because the player will always remember in the smallest detail any bright events that happen to him for the first time. It is the first impression that serves as the very model by which he determines the degree of visual appeal and the quality of graphics. Even if this event is repeated many times in the future, it still retains the emotional color that the player received first.

In cases where the gameplay is focused on exploring the environment, the player will also pay attention to the quality of details. Fig. 3 shows a scene filled with blacksmith attributes that is used by the player in the game's story. The purpose of drawing this location is for the player to recognize it for completing the quest.

Figure 3. Blacksmith location.

2.4. Perception of colour

Color is a powerful source of influence on the player's emotional state and perception of the environment. How do people perceive different colors and how to apply it in practice?

First, the color allows to make people feel warm or cold, a sense of fun, sadness or danger. The color temperature helps create the mood, and its changes add drama to the scene.

Using orange color, developers create warm and friendly atmosphere, thereby letting the player know that he is safe.

Prolonged exposure to blue colors creates a feeling of loneliness, isolation, alienation, indifference, sadness and coldness of the game environment.

When creating the environment of the game described in this paper, calm, muted shades of brown and gray were used, represented on the palette #1, associated with historical buildings for the starting first location in which the story is narrated, and the palette #2 was also used for placing soft accents.

Figure 4. First location colour set.

Dangerous places are marked in red, which provokes strong emotions such as danger, rage, anger and has an exciting effect. It is also read by the subconscious as danger, hostility.

When creating the second location, the enemy one, more red accents are used in the environment (Fig. 5). For example, the red sail and red cloth on the barrels draw the player's attention to nearby enemy characters.

Figure 5. Enemy location of the game with red accents.

Second, the same room or object makes a different impression depending on its color.

In interiors, it is necessary to use cold tones to expand the space of rooms, and warm tones to narrow their space. Rooms painted in blue, dark blue, green colors seem cooler, and those painted in orange - warmer.

Due to colors, we can give objects a sense of weight. The same object, painted in light or just white color, always looks lighter, and dark or black colors seem heavier.

Third, color helps create its own expressive and memorable image for each level. In other words, if a location has its own unique color palette, it will be much easier to remember.

2.5. Perception of space

Features of human perception of different spaces also allow to manipulate the emotional state of the player. By using the level geometry correctly, we can make the player feel secure, in danger, or fearful of heights.

An obvious way to create a feeling of claustrophobia is to use flooded or walled rooms, which forces the player to act decisively and explore the environment in search of safe places where he can get air or find a way out, respectively.

It is also possible to create the illusion of a closed space by reducing the viewing distance due to using fog, poor lighting, or limiting the camera's viewing angle. Darkness, eerie shadows, strange sounds and the maximum limit of visibility - all these things actively awaken imagination, and as we know, danger always looks bigger through the eyes of fear.

In the educational game being created, the first game location is limited by buildings on all four sides, and the storyline ends with a massive gate that is guarded. This provokes the player's curiosity and desire to get further, which contributes to the passage of the story by the player.

Figure 6. Massive gates at the story ending in the first location.

In its turn, open spaces with a small number of shelters will cause a sense of vulnerability. As a rule, people will avoid such places considering them dangerous. Open spaces are often used in levels that are arenas for boss fights. The created location for the final battle was no exception – the open area and elements of shelter disguised as game objects created a suitable atmosphere of struggle and danger (Fig. 7).

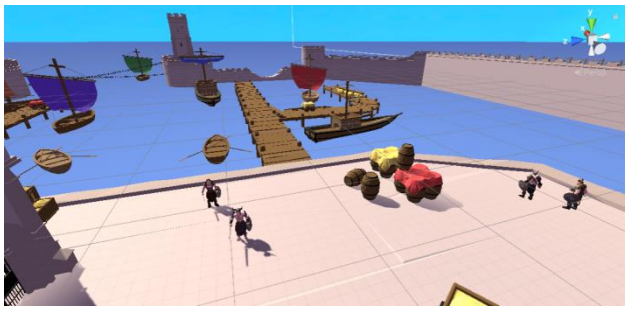

Figure 7. Final level design.

With the help of proper use of space, we can cause a person to feel afraid of heights. To do this, it is enough to offer the player to walk over the abyss on a narrow path from which it is very easy to slip.

So, we considered the most important features of human perception and found out that the first impression is important in assessing the quality of details, colors can influence the emotional state of people, and due to the proper use of spaces, we can cause the player to feel protected, dangerous, claustrophobic or afraid of heights.

2.6. Game interface development

Interface development is one of the most important stages of creating a game. The intuitive interface allows the player to understand the game mechanics better. The quality of the interface depends on the amount of fun that the user will get during the gameplay.

Creating a high-quality game interface requires compliance with a number of psychological and fundamental (logical) principles. The first ones are related to mental work and visual perception of information, while the second ones are responsible for the logical structure of the game UI.

When developing UI from the standpoint of fundamental logic, the following rules must be observed:

Do not use a large number of different elements (buttons, images, checkboxes). The complexity of the game mechanics should not negatively affect the structure of information in the interface;

All interface elements should be uniform — this will allow the user to reduce the time required to complete the game task and avoid making mistakes;

The game must support feedback from the player through the interface, so prompts should be displayed on the screen to explain the temporary unavailability of an element;

The interface must contain a minimum of text fragments. They should be replaced with icons or pictograms (adjusted for the need to localize the game). Information presentation should be attractive to the player;

Excessive elements in the interface design should not reduce its functionality and ergonomics, and should not increase the overall weight of the game;

Putting emphasis (color, size, animation) on important interface elements for the player.

These rules were used to create the game interface in the course of this work.

Fig. 6 shows the developed interface that is visible to the player during the game itself. Complex and multifunctional screens are divided into simpler ones with the optimal amount of information for perception: the quest and inventory windows are located on the opposite parts of the screen, while the quest window is divided into the task part and the cross item part, which are described as individual icons. The game screen is not cluttered with various buttons and windows, so as not to confuse the player. There are bright informative images, supplemented with the text, to increase readability and understanding of game mechanics.

Visual information is split in the game menu into groups by tasks and them are placed in the form of elements familiar to users (buttons) to speed up the player's adaptation and help him navigate (Fig. 8).

Figure 8. Game menu.

2.7. Using interface for implementing game mechanics

By using the interface to implement the game mechanics in this work we mean testing the student while passing the story and summing up the results, calculating the final score.

The testing itself takes place in the second location, full of enemy NPC. Each enemy is given a test question and answer options. When attacking an enemy, a task window and a timer clock pop up (Fig. 9).

Figure 9. Process of game testing with the timer clock.

After passing the entire test (10 questions – 10 enemy characters), the game ends. Using the rating system, we calculate the final result and the result is displayed on the screen (Fig. 10).

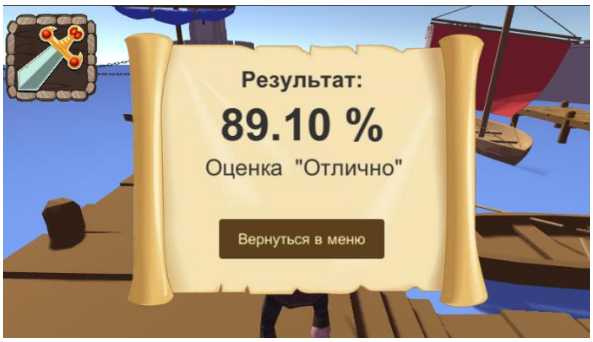

Figure 10. Results output on the screen.

Previously, the system for evaluating students' knowledge for this game was described in the paper "Development of an educational game with testing and evaluation system" [1], which describes in detail the approach to calculating the final score. Based on this paper, the testing presented in this work is a closed test task with a single answer, for calculating its credit score B this equality was used:

$$B = \begin{cases} B_{max}, \ if\ chosen\ a\ right\ option \\ 0, if\ chosen\ a\ wrong\ option \end{cases} \quad (1)$$

The evaluation score should not only reflect the quality of the knowledge obtained, but also the time spent on solving the task. To display the time interval in seconds that a student spent for a single test question, Δt parameter was entered . This parameter should affect the score so that B_{max} = [0;1]:

$$B_{max} - \Delta t * 0{,}01, \quad (2)$$

To limit changes in the score due to a new parameter, a time limit for one test task equal to 30 seconds was introduced. If the student fails in the time given, B is considered to be equal to zero.

Since the number of questions n in testing of this paper is 10, the formula for finding all the evaluation points for each question looks like this:

$$B_{\text{общ}} = \sum_{i=1}^{n} B_i + B_{i+1} + \cdots + B_n, \quad (3)$$

$$where\ B_i = \begin{cases} B_{\max i} - \Delta t_i * 0{,}01, if\ chosen\ a\ right\ option \\ \Delta t_i \leq 30\ sec. \\ 0, if\ chosen\ a\ wrong\ option \\ \Delta t_i > 30\ sec. \end{cases}$$

It should be noted that it will be almost impossible to reach $B_{общ}$= 10 because of Δt, so we also offer take into account the time to read the question and the reaction speed, which will reduce the maximum value $B_{общ} \approx 9{,}5$.

To define the final score based on the results $B_{общ}$, the limit of "passing" or the average score "satisfactory" is determined, namely, the student's result of at least 50% of the maximum $B_{общ} = 9.5 \pm 0.5$ is considered "satisfactory". Mark "good" corresponds to value $B_{общ}$ between 70% and 85%, and "excellent" - from 85%, respectively. Students' knowledge which varies from 30% to 50% is called the "area of uncertainty", and $B_{общ}$< 30% is considered the area of complete ignorance, which corresponds to grades 2 and 1 respectively.

3. Practical significance and the results of implementation

Based on the results of open testing in the process of teaching students, as well as a survey after passing the training game, the following conclusions were made concerning the use of three-dimensional interfaces in games, which are shown in Table 1.

Table 1. Results comparison.

Results of introduction Before\After		
	Before introduction of training game	**After introduction of training game**
Gamification of the training process	40%	90%
Involvement into training	59%	85%
Quality of knowledge obtained	62%	87%
Speed of training	52%	74%
Satisfaction	51%	83%
Comparison of used technologies		
	Educational games with 2D graphics and primitive interface	**Educational game, developed for this paper**
Graphics	+	+
Nonlinearity of level construction	-	+
Game mechanics	+	+
Realism	-	+
Students' preferences	-	+
Gamification of testing	-	+
Interaction of game objects	-	+
Survey of students after passing the game		
	No	**Yes**
Does the use of 3D graphics contributed to the study of the world and its history?	5%	95%
Does the developed interface help you get used to the game mechanics?	10%	90%
Would you repeat the experience of using educational games for testing your knowledge?	3%	97%

The result of this work is both a successful implementation of the game in the educational process, and the use of 3D technologies and interfaces in the development of the game. Their use not only increased the involvement in the process of mastering historical material, but also created a vivid impression of three-dimensional space while studying the game world. This combined with a well-

designed user interface not only increased the speed of learning, but also the correct understanding of the game mechanics, passing quests and final testing. Students noted the familiar elements of the user interface, which made the game easy to learn, as well as a pleasant color palette that does not hurt the eyes. Many agreed that the introduction of these educational games will significantly diversify their routine learning process.

Game interfaces are one of the most important parts of development. The game and the player live in completely different universes, separate from each other, and it is the interface that is the point of their mutual contact. Using the interface, the player receives information from the game, and the use of 3D technologies increases engagement and immersion into the game world, as it is a representation of the approximate reality that is familiar to us. It is through the interface and visual environment that the player learns the game. The quality of this interaction depends on the developed visual solution, a logical approach to building the interface that helps the player to understand the gameplay and promotes high-quality training.

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