Water transport information security trainer concept

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Abstract. The article considers the relevance of using game simulators in distance learning of information security students in water transport. The use of information security simulators for educational purposes ensures the consolidation of theoretical knowledge and their application in practice. It is very important that simulators, on the one hand, be close to real conditions, on the other hand, work on them is interesting and convenient for the student. The game mechanics used in the simulator are described. An example of calculating the risk of an emergency on a ship is considered, options for using calculations in the simulator are proposed. The concept of the simulator itself is described and the concept of the interface is developed.

1 Introduction

The use of information security simulators for educational purposes ensures the consolidation of theoretical knowledge and their application in practice. It is very important that the training simulators, on the one hand, be close to real conditions, on the other hand, work on them was interesting and convenient for the student [1].

Simulators created in the form of a game allow students to master new competencies with interest. Such technologies can become an effective tool in the educational process for teaching students new things or consolidating the material already passed [2]. Also, the passage of such a game can be set as homework, for the student's independent work. The relevance of such simulators is also emphasized by the possibility of using them in distance learning [3].

The use of a recognizable genre, which is familiar and popular among students in the virtual world, allows you to acquire positive emotions, increase interest and motivation for the development of cognitive activity [4].

2 Materials and methods

The use of simulators in teaching allows you to teach students the practical skills of working with something. As a rule, such an approach to teaching requires the student to

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know the theory of the subject, as well as to actively participate in the work. Thus, the student has the opportunity to demonstrate his knowledge in practice and improve his skills. Of course, no simulator will replace a real device or a real situation, but such an approach in teaching will help to consolidate the material and in the future the student, seeing a real object, will not be lost and will be able to calmly work with it.

For example, "Virtual complex" Protection of an object from leaks of information through technical channels", TZI-VIRT", the simulator is aimed at obtaining primary experience in preparing a room for certification, consolidating in practice knowledge on the physics of the formation of channels of leakage of technical information, familiarization with modern protective devices and methods of their installation, depending on the characteristics of the virtual office. This software package helps in the study of methods of technical protection of information. The program allows you to design premises, simulate threats and arrange protection against them.

Also interesting as an example is the software package "Virtual complex" Detection of embedded devices and hidden video cameras", RAM-VIDEO-VIRT". The simulator is designed to gain knowledge about methods for detecting embedded devices and hidden video cameras, as well as to gain experience with modern security tools designed to detect embedded devices and hidden video cameras.

An interesting option is to use the game as a simulator, when a student memorizes new material while playing and masters new competencies.

The use of game techniques in the lessons allows the student to acquire the following skills [5]:

- Make quick decisions and be responsible for them;
- Use the experience gained in performing professional tasks, determine the best solutions, evaluate their quality and effectiveness;
- Communicate with each other and foster teamwork;
- Take responsibility for the work of all team members, for the result of assignments.

To date, many interesting educational games have been created that help to consolidate this or that material, but they are not structured into a single course on information security and are suitable only as an auxiliary environment for studying certain topics.

Using game technologies in pedagogy, it is necessary to go through several main stages, which include drawing up and planning goals, defining tasks and plans, and, finally, completing the assigned tasks. It is necessary to discuss and analyze with students the whole process of work and the results obtained.

Any activity makes sense when these conditions are as close as possible to real life. The student must have a voice, discretion and responsibility. Only if these requirements are met, a person fully defines himself as a specialist.

The classification of educational gaming technologies is quite large. So gaming educational technologies are usually classified by the field of activity, by the nature of the educational process, by the method of the game, by the subject area, by the game environment, etc. Within the framework of this article, an intellectual, educational, simulation computer game on information security in water transport will be considered.

The classification of computer games is also varied, but we will pay special attention to adventure games, strategy games, puzzles, computer simulations and educational games. All these genres can be used when teaching students and staff any new competencies.

3 The concept of the simulator

The purpose of the simulator is to create a learning environment where cognitive and training activities will be available in a playful manner that is interesting for the student. The simulator should consist of a plausible small boat model. The student will have to be able to choose protection equipment and install it on the object. There should also be access to the ship's computer interface for "installation" and operation of the software [6, 7]. You can also add the passage of mini-games to the main program for learning, mastering or repeating certain competencies. These mini games can be used individually or as a quest.

For the correct placement of protection equipment and installation of software, the student will need to have knowledge of the legal framework, as well as to calculate the risks [8, 9].

The game will contain the following objects:

- components of the security system;
- ship cabins;
- captain's bridge;
- equipment of the vessel.

This plot has the following attractive features:

- The theme of a real ship is used, but students dream of getting a real experience;
- The variety of ship equipment, work situations and work responsibilities of an information security specialist creates a lot of potential for the development of the plot;
- You can add secret levels for those who want to further study the material on the game.

Table 1 below presents the interpretation of the elements of the mechanics in the context of the game plot and setting:

Table 1. Interpretation of elements of mechanics.

Element of mechanics	Item description
Points for solving problems	Points in individual player ratings and points in student ratings on the course. The ratings are divided according to the competencies that are studied at one level or another.
Points for finding items	Points in individual ratings and points in student ratings by competency.
Points for the correct use of items	Points in individual ratings and points in student ratings by competency.
Ranking among all students	Ratings between students and the rating of the player himself.
Levels	Divided into competencies, according to complexity
Helping the student to complete the assignment if the assignment takes too long	The task can be completed no longer than two hours or lesson, depending on the level. If the player completes the task for a long time and cannot solve the problem, but also does not take hints, the gameplay prompts him to the correct way out of the situation.
Limiting lesson time	When the time ends and if the task was not done, then the student receives a "reprimand" card, if the student accumulates a certain number of such cards, then he will need to go through the game again. If the task was done, but with errors, then the student is invited to redo the work. If everything is done correctly, "the manager gives a new task to the employees."
Penultimate level reached	It is proposed to pass the last level, which will be a practice-oriented examination task. In this task, the student will need to use all the knowledge gained earlier. This level should correspond to all competences of the discipline.
Reached the last level	The student receives a full report on what competencies he has learned and where he made mistakes. It is also possible to view such reports after passing each level.

Performing three tasks at once quickly and without errors and without asking for hints	The player receives a bonus item that gives additional opportunities when solving tasks.
Completed the level on your own without asking for hints	The player receives a part of the "magic" item, if the player collects the "magic" item, he can exchange it for points in the rating or for additional opportunities.
All levels are completed independently, without prompting for tips and correctly	Additional points are awarded in the rating.
The player did not complete the levels at the end of the game time	The player is asked to play the game first before completing the additional session. 3 additional levels are also added
The minimum number of points or below the minimum at the time of the end of the game	The player is invited to go through three additional levels.
Not a single task was completed correctly	The player is invited to go through some levels again, and it is also proposed to go through three additional levels.
All tasks are completed with tips	The player is invited to go through three additional levels, without the possibility of using hints.

Thus, the following game mechanics will be used in the work [2]:

- Mechanic "Achievement". This mechanic is based on a material or virtual expression of the result of performing an action. The results can be seen on their own or as a reward. Anything can be a reward;
- Avoidance mechanic. With this mechanic, the player is motivated not by a reward, but by the fact that he can avoid punishment. This usually helps to keep the activity level consistently according to the schedule provided by the developer;
- The Reward for Effort mechanic. The idea behind the mechanics is that when you play, you feel more joy from work than from rest;
- Mechanics "Chain of events". In this mechanic, the reward is used as a link in a chain of related events. In many cases, players see these events as separate elements. When a link in a chain is unlocked, the player perceives this as a reward for the actions taken;
- Mechanics "Countdown". Applying the presented mechanics, it is necessary to create situations when a limited time is allotted for solving problems or overcoming obstacles. Using this method, you can increase the activity of the players and increase its performance compared to the original. However, it is important to understand that activity only increases for a limited period of time;
- Mechanics "Combined rating of winners". Mechanics are used when there is a need to use a common scoring system for a number of game scenarios, and they can be completely dissimilar and unrelated to each other;
- Mechanic "Reward for a specific sequence of actions." Players are rewarded not for one, but for several consecutive actions. At first, the technique can reduce the activity of the participants, since the action does not bring a reward, but later it increases, because the time for receiving the reward is approaching;
- Loyalty mechanic. The mechanic of loyalty is to establish a non-verbal relationship between the participant in the game and the reality of the game. This connection is achieved by introducing a person to his participation in the game world (for example, he may have

real estate in the game), and then this is enhanced by visual images that other players can see;

- Meta-game mechanics. The meaning of this mechanic is that an additional one is built into the main game. During the game, the participant can find an additional game, because the author does not advertise its presence, so as not to create confusion or increase interest in the game. But the developer's advantage is that when players find meta games they are usually very happy because it creates a pleasant surprise effect;
- Mechanics "Micro-competition". Used when working with mini-games. It allows you to form mini-scores and is most suitable for games with several game mechanisms, as well as for situations with a large number of mini-competitions. It is easy to increase the loyalty of game participants with the help of a varied system of rewarding winners in mini-games;
- Mechanic "Modifiers". In the mechanics under consideration, a certain object or artifact is used during the game, the use of which affects the results of tasks. This is called a modifier. Often the player earns it by completing a series of tasks or performing a series of important actions;
- Mechanic "Pride". Based on positive feelings from the achieved result;
- User progress mechanic. It is a mechanism that reflects the progress of the player in completing the tasks assigned to him by the game;
- Instant reward mechanic. The player receives all information about his position in real time. As a result, he instantly reacts emotionally;
- Real Prize Distribution Mechanics. When using this mechanic, the player receives a reward that is of real, tangible value to the player for the results of the game. Each player can receive such a reward if they meet certain requirements or receive exceptional results.

Plot arc: the protagonist is a specialist in an information security services firm. He is tasked with improving the security system on the ship. Passing each level, he must solve information security problems close to real conditions. It is necessary that after passing the game the student masters certain competencies.

It is also interesting that the teacher can change the sequence of levels; the teacher can even remove some levels if he considers them not suitable in his course. To do this, the teacher will need to go to the "level constructor".

3.1 Level example

For example, consider the level of definition of the risk of an emergency, which is planned to be implemented in the near future.

At the initial stage of the game, students can be asked to calculate the possibility of an emergency on a given vessel. You can also give students the opportunity to choose a level: "Easy", "Intermediate", "Difficult". The selected level will determine the maximum number of points that a student can score when passing the level.

When choosing any level of difficulty, the student will be asked to take a training test, and if the test is successfully completed, the task will gradually open. When choosing an "easy" level, the student will need to choose from several proposed forms with the correct formulas and substitute parameters there based on the route of the vessel, the cargo being transported, the type of vessel, etc. When choosing a level of "medium" complexity, the student will need to draw up a form with formulas himself, but he will have the opportunity to refer to a short synopsis of theoretical information. And when choosing the "Difficult" level, the student will not have the opportunity to refer to theoretical materials. At the "intermediate" and "difficult" level, it is worth adding a "check" button, when the wrong

decisions of the student will be highlighted during pressing, but it is worth limiting the number of clicks on this button.

The risk assessment of emergencies in this example is determined using statistics, route, etc. The model, which will describe the state of the ship's safety using risk assessment, is based on the statistics of emergencies in water transport. Statistics allow you to determine the type of flow of extreme events, as well as the trend equation [10-12].

To solve this problem, let us consider a statistical model of safety in water transport, taking into account the limited time interval τ. Based on Poisson's law, consider the probability that k events will occur:

$$P\{X(t,\tau) = k\} = \frac{a^k e^{-a}}{k!},$$

where P is the probability of an event occurring; X (t, τ) is a function of k – the number of random hazardous events during the time τ; $a = \lambda\tau$ and λ is the intensity of the flow of dangerous events.

We can consider the general flow of random hazardous events in water transport as private flows of random events connected together for a number of causal factors. The sum of independent Poisson flows is also a Poisson flow [13, 14].

It was also taken into account that the occurrence of emergency situations in water transport can be defined as a sequence of incompatible events Alj and joint events Bi. Incompatible events Alj may include technogenic threats of the type (j = 1, 2, ..., J) in the navigation area l (l = 1, 2, ..., L), for example, failure or breakdown of navigation systems. such a threat could be the cause of an emergency: grounding, collision with another vessel or coastline, deviation from the route, flooding, etc. It should be noted that an emergency on a ship can be the result of only one of the many considered joint events Alj [15, 16]. The type of consequences i can be different, for example, flooding, grounding, fire, crash, collision.

Let Njil be the number of ships that have suffered corresponding accidents due to the onset of a man-made threat of the j-th type with damage i in the considered navigation area l, and Nl – the total number of ships in the considered navigation area l. We can determine the probability of a man-made threat of type j causing damage i in the navigation area under consideration l using the formula:

$$P(A_{ji}^l) = \frac{\sum_j \sum_i \sum_l N_{jil}}{\sum_l N_l}.$$

The weighted estimates of failures can be calculated using the formula:

$$\omega(A_{ji}^l) = \frac{\sum_l N_{jil}}{\sum_j \sum_l \sum_i N_{jil}}.$$

It should be borne in mind that the causes of an accident taken from statistical data can be subjective, since decisions about the specific cause of the emergency are based on expert judgment. An expert opinion is accepted during an official investigation of an accident in water transport [17, 18]. Therefore, we can get only the "subjective" a priori probabilities of the event Alj, and events Alj and events Bi will be considered as hypotheses. Let P(Alj) be the probability of hypothesis Alj and $P(B_i|A_j^l)$ – conditional probability of the event Bi under the hypothesis Alj.

Based on Bayes' theorem, it is possible to determine the probability of hypotheses that caused the event Bi [19 - 21]:

$$P(A_j^l|B_i) = \frac{P(A_j^l) \cdot P(B_i|A_j^l)}{\sum_{j=1}^{J} \sum_{l=1}^{L} P(A_j^l) \cdot P(B_i|A_j^l)},$$

To predict and calculate the intensity of emergency situations due to natural disasters, unpredictable events, unfavorable weather conditions in the time interval Tl for region l, statistical data are required [22]. If we consider one ship whose route passes through region l, the intensity of emergency situations can be calculated by the formula:

$$\gamma(B_i|A_j^l) = \frac{\sum_j \sum_l \sum_i N_{jil}}{T_l},$$

if there are some ships then by the formula:

$$\gamma(B_i|A_j^l) = \frac{\sum_j \sum_l \sum_i N_{jil}}{T_l \cdot \sum_l S_{T_l}},$$

where $\sum_l S_{T_l}$ is the number of ships passing through region *l* during time T_l.

Let W_i^l be the amount of possible damage *i* in the considered navigation area *l*. Thus, we will calculate the level of emergency risk:

$$R_i = \sum_{j=1}^{J} P(A_j^l) \cdot R(B_i|A_j^l),$$

where $R(B_i|A_j^l) = \left(1 - exp\left(-\gamma(B_i|A_j^l)\right)\right) \cdot W_i^l$.

The assessment of the risks of emergencies in water transport along the given routes can be presented as a sum of risks [23, 24]:

$$R = R_1 + R_2 + R_3,$$

where R1 is the risk of a natural disaster (natural threat); R2 is the risk of realization of man-made threats; R3 is the risk of realization of anthropogenic threats.

All of the above can be used as theoretical information for calculations. You can also consider several ways to calculate risk.

3.2 Interface concept

After loading the game, the user must have access to the menu: continue the game, select the game, select the level of the game, select the mini-game, view reports, ratings, settings, view controls, information about the game. Also, the user should be able to exit the game and return to the main menu and exit the main menu.

The game screen should display the time remaining until the completion of the level, place in the rating, level number, location (depending on the task), equipment (depending on the task).

Consider the use cases in the game menu presented in Fig. 1a.

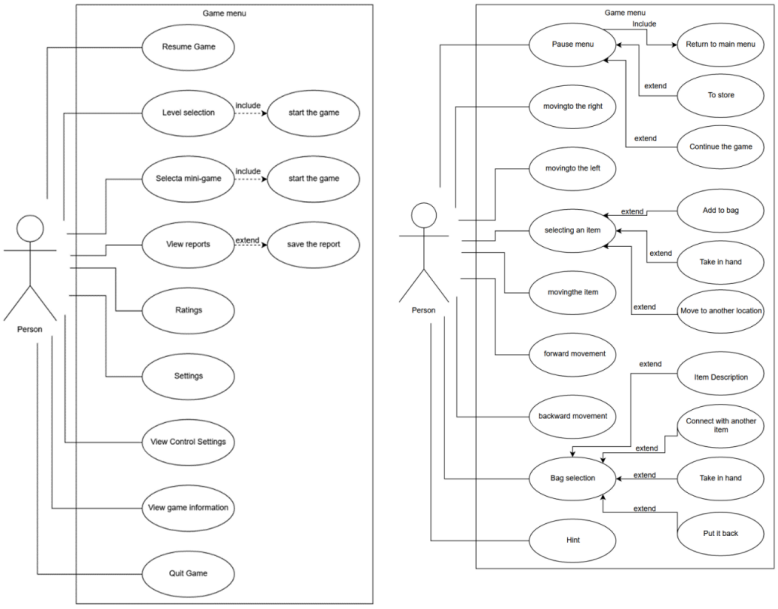

Fig. 1. Diagram of use cases in the game menu (a) and in a game scene (b).

Resume Game: The user can return to a saved game.

Level selection: the user can switch to a map with game levels, then he must select a level and start the game.

Select a mini-game: the user can switch to a map with mini-games, after which he must select a mini-game and start the game.

View reports: the user can view reports on the game, see what mistakes he made, which competencies he mastered better and which ones were worse. It is possible to save the report.

Ratings: User can see their rating in a group or among all students on the course..

Settings: the user can enter the settings menu, mute the sound, or select the volume. Turn off music. Choose a language.

View Control Settings: The user can perform a Control View to move around the playing field and manipulate objects.

View game information: the user can view information about the game, goals and objectives of the game.

Quit Game: The user can log out of the game.

Next, consider the use cases in the game scene, presented in Fig. 1b.

Pause menu: the player can pause the gameplay (if after 15 minutes the player does not return, the main menu opens). Then he has to resume it or go to the main menu.

Controls: the user can control the behavior of the character by moving to the right, left, selecting an item and moving the item.

Bag selection: the player can look at the items that he has in the inventory. They can be connected and modified, or taken in hand.

Hint: The player can ask the game for a hint.

The player is responsible for moving the character around the playing field and manipulating objects. The character must move on the floor, not bump into obstacles in the form of furniture, take various objects. The level is considered not passed in the following cases:

- playing time ended, and the player was unable to solve the tasks assigned to him;
- the player solved the problems with errors.

Consider the activity diagram (Fig. 2). This diagram shows how the structure of a typical problem in the game will look like, i.e. structural element of the quest. Any task can be completed in at least three ways: the path where the user can make a mistake, the path where the user can complete the quest, and the path, and the path where the user does not have time to complete the quest.

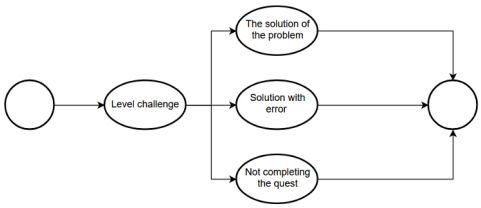

Fig. 2. Diagram of activity of the general case.

A non-linear sequence of related tasks defines the plot [25]. The possibility of three endings for all tasks performed is considered. The student's performance of the tasks depends on the available ending options. If the student completes all the quests correctly, then he gets the maximum mark for the game. If a student completes the tasks incorrectly, then the student receives an average grade and two options, either to stay with the grade he earned, or to go through additional quests to increase his grade. And if the student completed all the quests with gross errors, or did not complete them at all, then the student is invited to go through the game again, or be left with an unsatisfactory mark for the game.

The game is located only in one location - the ship, for which it is necessary to choose the means and methods of information security. The player sees the ship only from the inside.

Some quests will be implemented by the mechanics of dialogue, when it will be necessary to write letters to employees in compliance with the rules of business correspondence, where at each stage there is a choice of three options, each of which has its own consequences. If a student makes gross mistakes when solving a problem, then he will have to go through the quest again in order to get points for him.

4 Conclusion

The use of game mechanics in staff training is a fairly effective way of presenting information, which is aimed at increasing students' interest in their chosen profession. Simulators help students to try their hand at practice. By combining these two educational technologies, you can get a simulator on which the student will be interested in practicing and improving his knowledge.

We should also single out Sergey Kolesnichenko for his quality advice when working on an article. We should also thank Alexey Astapkovich for his help in checking the text and creating a working environment.

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