Teaching industrial plant using serious games

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***Abstract*—The development of tools that assist teachers in the teaching process and stimulate students to remain attracted to the subject being presented is a very important topic. This paper aims to present a serious game type simulator that can be used by students in high school and university. The simulator is intended to help the students to learn topics in physics and industrial automation by providing the simulation of the development and experimentation of industrial plants. Thus, it brings to the students an interactive computational environment to study the phenomena that are present in industrial processes.**

***Index Terms*— Serious Games, Industrial Plants, Education**

I. INTRODUCTION

Educational processes are under constant change over the years, boosted by techniques and tools that come with the intention of adding ways to improve the absorption of knowledge presented, and also provide more effective, dynamic and diverse forms of learning.

The principle of simulation facilitates the cognition, develops skills and beliefs on topics through practical experimentation and eliminates the need for tactile features that were necessary for the study of the processes involved in real environments. According to [1], the simulation allows us to check the operation of a real environment in a virtual environment, generating models that behave as reality, considering the system variability and demonstrating what will happen in reality, in a dynamic way.

The development of educational simulators are inserted in the field of serious games, an area that presents real expansion and acceptability in the current market, where consolidated companies focus their attention to use this technology as tools in different areas of activity. As examples of companies that use serious games and simulators for employee training, we can cite McDonald's, Burger King, Coca-Cola, Intel, Petrobras and Navy of Brazil.

This paper presents the development of a serious game for teaching industrial plants concepts to high school and university students. It is structured in 5 sections. The theoretical basis is presented in section 2. In the section 3, the proposed game is presented and in the section 4 the partial results of work are presented, Section 5 presents the conclusion and the future works.

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II. THEORETICAL REFERENCE

A. Serious Games as Teaching Tools

It is observed in the literature a large volume of studies in which the main aim is to validate the use of educational games and simulations in educational process of children, youth and adults. In most cases, positive skills were expanded as assimilation, acceptance and conviction about the topics covered. In general, the explanation most used by researchers in this area points out that with the use of simulators and educational games the knowledge transfer becomes more intuitive. In this way, the player/student learns in a dynamic and enjoyable way [6].

It is important to note that the concept and use of games as a way of learning is not new. Games have been used for education and training in various areas for a long time. As an example we can mention the “Army Battlezone”, a project developed by Atari in the 80s, designed with the purpose of developing new forms of military training in battlefield situations. Since then, the development of this type of game presented a steady increase over the years and is used in numerous areas, such as oil industry, automotive industry, airline industry, management training, personal management, accessibility for people with special needs, medicine and so on. To better understand the application of simulation in education we follow [5]. According to [5] simulation is a form of experimenting new ideas and concepts under conditions that would be impossible to be obtained in the real world due to factors such as risks, costs or time.

In this way, it is possible to observe the importance of simulators and educational games as tools to learning process in different fields of knowledge, especially nowadays, where technology and video games have an increasingly participation in life and training of young people.

B. Industrial Plants

The development of Industrial Plants involves well structured procedures that make up a series of mechanisms that are part of the manufacture of one or more items.

The represented processes and the different structures that make up an industrial plant (see Figure 1) are supported by international standards that provide high level of use in all production levels, as evidenced by the components of the system. They can be stipulated in development, providing better strategic use of resources and enabling technical feasibility analysis, economic feasibility, aesthetic, product ergonomics and environmental impact [3].

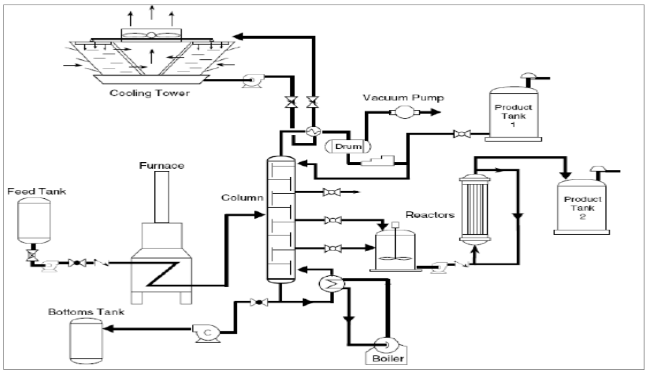

Fig. 1. Example engineering flowchart P&ID [4].

The development of industrial plants employs sets of dynamical systems. These dynamical systems can be modeled physically through the implementation of pilot plants based in prototypes or through their representation in mathematical models where the reality is abstracted in equations. According to [2], a mathematical model "is a representation of the essential aspects of a system that has knowledge of its system into a usable form." To [3], an industrial plant "is a system of equations with a solution, basing in a input data set that represents a process response."

III. The Proposed Game

Industrial plants are an important subject for learning in technical and engineering courses, because they are highly used by industries. However, it is a complex area (there are a very large variety of components and rules) and it is quite dynamic (for each situation, a different component must be used). In this way, we have decided to model this subject using a serious game, making the process of learning more fun.

The proposed serious game was developed based on software engineering principles [8] [9] [10]. All the modeling of the game can be found in [1].

The proposed game uses gamefication ideas [11] in the score of the game (the time to conclude each phase) and the rules to solve each phase (for example: the cylindrical tanks cannot link to control valves directly and hydraulic pipes are necessary). In this game, there is not a "game over". All students will conclude each phase, with a different score (the time to solve the problem), but the idea is that in a second time playing, students will finish each phase faster.

The game was developed in Java and in its current version it has three phases. In each phase, the student can structure the solution to solve a problem through the development of an industrial plant, initially handling the following components: cylindrical tanks, control valves, hydraulic pumps and hydraulic pipes. Each phase has a complexity level related with the number of available components (in the first phase, the simpler, there are just three components). The next phases are more difficult to complete, thus the learning is incremental.

As part of the learning process, the student must configure and connect the components. He/she should change the parameters, as tank dimensions, the connector diameter or the pump power. After this, the student will simulate the process in a dynamic interface. Therefore, the student can stop the simulation and can change the values at any moment, until the simulation occurs in a correct way. The interface shows the values during the simulation, to help the students to better understand all the process.

Because the game is a challenge at the start of each phase an explanation screen is presented. In this screen a problem to be solved as well as brief explanations of how the students manipulate the components are showed. In each phase the time to solve the problem is recorded and a score is showed to the students. After the third phase the student obtains a final score and can compare it with the score of the other students.

At any time, the student may require a brief explanation or specific help about any component. In such case the interface presents a explanation of the equation used to model each process and how to use it in this game phase.

Figures 2, 3 and 4 show the interfaces of the game of each phase (first, second and third phase).

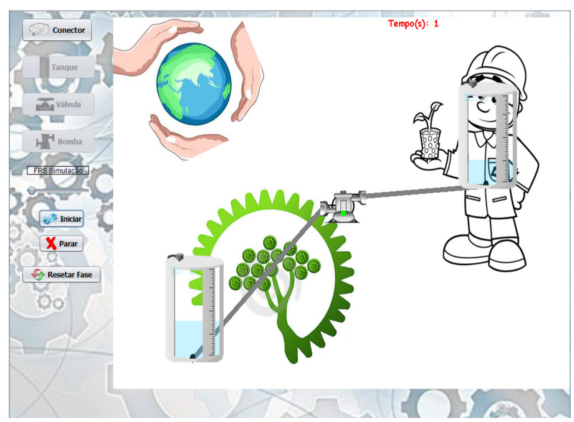

Figure 2 . Game First Phase.

In the first phase, the student must transfer water from the first tank to the second tank. It is a simple challenge, but it helps the student to understand the components and provide a quick solution. The second phase requires a similar reasoning as the first phase. However, in second phase there are two tanks that need to be connected in level to have water in equilibrium, thus, the power of the hydraulic pump must be configured to pass a higher volume of water to the other two tanks. In the third phase, the problem is to fill three different types of tanks (small house, medium house and apartments). To turn the problem closer to reality and to add some difficulty to it in this last phase the apartments' tank is larger, therefore, the student must change the flow rate to reach a good score and finish the filling of the tanks together.

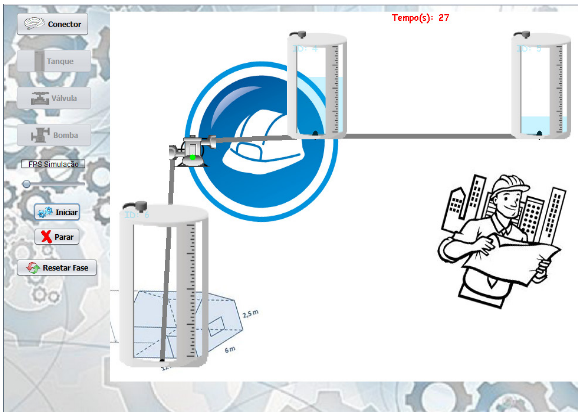

Figure 3. Game Second Phase.

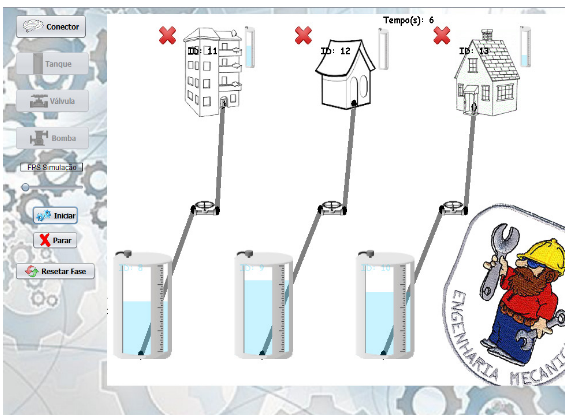

Figure 4. Game Third Phase.

Throughout the game, the student plays the game by configuring the simulator components. All the configurable parameters, game sets and data are recorded automatically in a database. Our idea is to analyze, in the future, the profile of players (There are different ways to learn? How do the students decide to change the parameters of the components?).

The database was implemented using PostgreSQL. The database contains six tables: User, which stores the student name and game date; Phase, which stores the phase data, as time; the other four tables (cylindrical tanks, control valves, hydraulic pumps and hydraulic pipes), store specific parameters of each components, as power or diameter (Figure 4). Each time that the student changes the values of each component, the database is updated.

IV. Parcial Results

We have tested the game with twenty five high school students (two groups) during the development of the game. The first student group tested the first phase, where some problems and difficulties were found. Their suggestions have helped us to improve the game experience. Considering, the players suggestions, the game was changed to make it more attractive to new players.

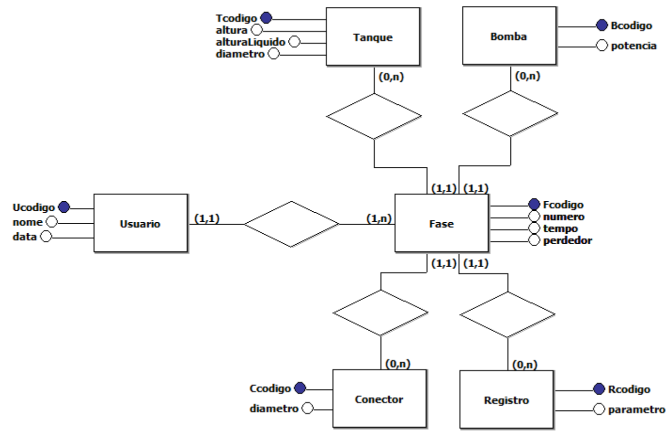

Figure 4. Data base entity model

The second group tested the first and second phases. They suggested some new tools/components, as for example the time (score) and the help during the game (explanation about each component).

The next step is to implement the fourth phase, where the student will enter in an extra phase with an empty scenario, but with a specific problem to solve. This problem could be: “There are three houses that need to link water from a single cylindrical tank. How to assemble this structure? Which components could you use?”. The students will have the freedom to assemble his/her own industrial plant and simulate this process. In this way, he/she will test new combinations of hydraulic components or to repair his/her doubts. To evaluate the fourth phase, we will verify if the student proposed solution solves the problem using the minimal components to it. If the student has used a bigger number of components, but the solution is correct, he/she will receive a lower score.

V. Conclusions and Further Works

In this paper, we presented a serious game with the proposal to teach industrial plants concepts to high school or university students.

We believe that the use of serious games can provide a motivational factor for the teaching of disciplines called "difficult", in a playful and intuitive way. Our game was implemented based on design patterns as modularity and reuse.

It was developed in Java, in order to ensure its portability. The game has been tested with high school student groups to check the usability and understanding of the game as well as store their moves to populating the database. As further works we will analyze these data and we will apply data mining techniques to identify players' profiles.

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