CONCEPTUAL MINI-GAMES FOR LEARNING

Ana Isabel Illanas, Francisco Gallego, Rosana Satorre, Faraón Llorens
Dpto. de Ciencia de la Computación e Inteligencia Artificial. Universidad de Alicante
Alicante / Spain
{aillanas, fgallego, rosana, faraon}@dccia.ua.es

Abstract

The increasing popularity of computer games has turned children and teenagers into regular users. Serious Games expect to give them more than just entertainment. Although the development of Serious Games is increasing, there still are few companies, studies and research groups dedicated to this area. Also, most projects in this field target sophisticated and costly-to-develop computer games aimed to cover a wide range of academic content. Therefore, these games lose concreteness and complicate the evaluation of their real educational value, making it difficult for students to focus on important concepts. Moreover, these games are not reusable and it is extremely difficult for students to follow more than one of them in an effective way.

This paper evaluates and proposes serious mini-games as a solution. In particular, it presents and develops what we have called "conceptual mini-games". A conceptual mini-game is completely focused on a concrete concept to be taught, in order to transform the game into a learning object. Conceptual mini-games make the evaluation of their real educational value easier and they are very reusable. As an example, we have developed MemOwl, a conceptual mini-game for memory development.

Keywords

Serious games, mini-games, conceptual mini-games, education, teaching, active learning, learning object.

1. INTRODUCTION

Nowadays, in spite of linking computer games to leisure time, it is possible to start considering them a "diamond in the rough" to increase school motivation. New generations are surrounded with all kind of multimedia technologies which logically attract their attention more than school lessons. It is necessary to start to play in the students backyard to increase their wish for learning. Computer games are suitable for this because students know them and are attracted by them. Computer games with a good educational content can be very useful for students to acquire knowledge without noticing it [1].

Many authors have used commercial computer games or they have developed large computer games for learning, more or less successfully [1][2]. But it is still difficult to find a commercial computer game which fits in the particular necessities of a subject [3]. Furthermore, it is very hard and risky developing large computer games for education. On the other hand, this kind of computer games covers too much stuff so the evaluation of their real educational value is complicated. It is difficult for students to focus on important concepts.

In contrast, this paper presents mini-games as a solution. A mini-game is a short computer game with basic rules and easy to play. This article is going to present a specific kind of mini-games we have called "conceptual mini-games". A conceptual mini-game is a mini-game aimed to teach a specific concept. Conceptual mini-games are in charge of a certain concept and they exploit it by means of simple game rules. Furthermore, conceptual mini-games can be applied to a large range of subject matters and teaching fields. As mini-games are not big projects, they are not hard to develop and they can quickly increase their number.

In spite of their advantages, few authors have considered the use of mini-games for education. This paper studies the advantages and disadvantages of conceptual mini-games and describes a conceptual mini-game created by the University of Alicante.

Firstly, there is a short introduction of the present state of computer games in general and the world of educational computer games in particular. The second section talks about conceptual mini-games, its definition and characteristics. It is important to distinguish conceptual mini-games from large

productions so this section explains the advantages of conceptual mini-games in regard to large computer games in academic fields. The next section talks about an educational conceptual mini-game created by the University of Alicante. It is a conceptual mini-game for memory development and it will be the first in a large collection. This example is useful to analyse the advantages and disadvantages of this kind of mini-games in education. Finally, the conclusions and references close this paper.

2. COMPUTER GAMES FOR LEARNING

The market of computer games has increased considerably in the last few years [4][5] and, far from stabilizing, it tends to continue rising. Furthermore, this market is increasing the range of age of its customers [5]. Technologies for computer games development are more and more innovative. These technologies increase realism and attractiveness of computer games. Furthermore, new user interfaces allow for the coverage of a larger range of possible customers from different social groups. People who are unable to play with keyboard, now can play with a tactile screen, a video camera or with new control pads which are able to detect real player movements.

There are different opinions around the benefits of using computer games, above all if children are the main consignees. Computer games are highly addictive which could make children overlook necessary things for their development. However, it is difficult to avoid children from playing computer games so it is better to stop considering computer games as a threat and start to take advantage of them. If computer games characteristics were analysed, it will be possible to discover why they are so attractive and this information could be used in other fields. Nowadays children are surrounded with technological and multimedia products and they consider traditional methods for learning to be really hard. Children are becoming less and less motivated to study and knowing new things doesn't attract their attention. So it is important to understand what things are attractive for new generations and find the best educative use for these things.

There are some factors that computer games contribute to players without them noticing it. Mental sharpness and reflexes are skills which get intensely favoured when using computer games [4][5]. Nowadays, with new technologies and new peripherals, it is possible to exercise the coordination of other parts of the body different from hands and fingers [5]. Moreover, recent studies reveal that players prefer to play with other people [5]. This is a good sign because in a multiplayer computer game, teams work and competitivity will be increased [4].

With regard to aggressive behaviours there are some studies that declare that there are no differences between people who often play computer games and people who do not. Even on the opinion poll, both adults and children agree in television and cinema contain more adverse content [5].

There is a world around computer games development. There are a lot of mechanisms to study the impact of computer games and obtain the best results. Final user profiles are taken into account and these characteristics are carefully researched to be incorporated into computer games. If this research is well-done, an attractive and addictive product will be produced.

If a similar study was carried out with regard to the educative uses of computer games, it would be possible to effectively use computer games to improve teaching. It is possible to have children learn without noticing it through the use of computer games with educational aims but it is necessary to maintain the main characteristics which make games addictive.

Teaching staff have always tried to base on different activities to supplement theoretical lessons with the aim of leading students to respond in a positive way. Documentaries or history films are clear examples. These materials have always been well-know to be very useful in teaching when there is a hard-to-understand lesson. Concepts are easier to understand if they are presented with images [6]. However, these are still passive methods for teaching where students are sat and receive the knowledge in a visual and auditory way. After a lesson with these materials, it is still normal that some students had not understood the message because they were not paying attention.

Using computer games as complement for traditional methods for teaching is not a passive method. The best characteristic of computer games is to be greatly immersive [2]. Player is immersed in the game and takes part of it in an unconscious way. Immersion causes the feared and criticized addictiveness. However, a controlled addictiveness over an educational framework is not an inconvenient, but an allied. An addictive educative activity guarantees learning continuity. This is an active method where user is part of teaching [1][3]. In this manner, players will discover the lesson by themselves and at their own pace. In our education system, this is very important because there are a high number of students per classroom. Each student has different capabilities so giving them a uniform lesson level is not realistic. Some of these students will not achieve the general level and

others will find it to be too easy. With a computer game as learning method, each student will get the appropriate level according to their capabilities, avoiding a uniform classroom speed, too high or too slow, which damages student development.

In this kind of teaching, teacher becomes supervisor and guide. Teacher explains theoretical concepts in the classroom and students practice them through the computer. Teacher can easily oversee each student and observe their development. Students marks are the levels they get in the computer game. Motivation and interest are guaranteed thanks to the immersion that students experience when playing computer [1][2]. Students are totally immersed in the lesson. This is the most active teaching method. Furthermore, computer games can recreate any stage or virtual environment for better practicing and understanding theoretic concepts [2]. It is possible to experience anything without any risk in safe environments. This characteristic allows for computer games application area to grow considerably faster than any other teaching method.

3. CONCEPTUAL MINI-GAMES

The main intention of serious computer game for learning is to lead without noticing it. Furthermore, their content and teaching methods beyond these games must be reliable for parents and teachers. However, it is necessary to find the kind of computer games which is suitable for each specific content to be taught.

To develop a large computer game is generally too costly. It is necessary to study which contents to teach through the computer game and introduce them carefully in the argument of the game. It is important to be careful not to lose some computer game essence. The development of a large computer game generally covers too many subject matters. This fact complicates the evaluation of their real educational value. Furthermore, players can be easily tired before completing this kind of computer games. There is a considerable percentage of users that leaves a story because it is too long.

There is a good alternative for large computer games which teach a lot of concepts. This alternative consists in producing a collection of short computer games (mini-games), each one focused on a certain concept to teach. We have called this kind of mini-games *conceptual mini-games*. A mini-game is a computer game with basic rules and easy to play. A conceptual mini-game uses the advantages of mini-games to teach a specific concept. Conceptual mini-games are created by selecting a concrete concept to teach and then designing a mini-game focused on that concept. In this sense, conceptual mini-games can be considered as learning objects. As long as mini-games are created this way, it will be easier for students to receive the correct information and learn from the mini-game. A conceptual mini-game tries to teach a specific concept by means of an easy-to-understand practice. Furthermore, when conceptual mini-games are used, it is easy to evaluate the real educational value.

Conceptual mini-games have very simple rules which do not change along the game. Thanks to this, it is easy to evaluate the progress of students. This paper bets on a kind of mini-games with infinite playability, that is, they finish when user stops trying to achieve a better performance level, like if they were sports, for instance. They have not a definite end of the game so they are endless and only finish when user fails. This characteristic is probably the most attractive of mini-games: they encourage players to break themselves. In each game, players try to break their previous score. Conceptual mini-games increase their difficulty as the game advances so meet with success is more and more complicated. Conceptual mini-games can be confused with collections of computer exercises but they are not the same. Conceptual mini-games are for playing, rather than just for practicing, and users acquire knowledge in a transparent way: they play for fun and learn while playing.

Furthermore, conceptual mini-games are not costly to develop so there are a lot of possibilities to increase their number. Finding the optimum mini-game for each concept is the most difficult. A balance between fun and education is necessary. It is important to carry out studies about how to teach specific concepts without boring the player. For example, trying to teach students how to solve additions without making them feel the repulsion they usually feel against maths. If players feel that the computer game is just an educative exercise, they will lose interest in it easily.

If the intended public of the conceptual mini-game is older, it is possible to develop another kind of conceptual mini-games where the educative aim is not hidden. This is the situation of the famous computer games for brain training. They are a mini-game collection for mind stimulation in different fields. These mini-games are extracted from brain researches and they are adapted for new technologies. There are tests for different brain characteristics by means of calculus, logics or association exercises. In this case, knowing the computer game aim have increased the interest of people and have enlarged their success in the last few years [5].

Conceptual mini-games application field is very large. These games can be adapted to any concept to be learnt and end-users could be of any range of age. Furthermore, a conceptual mini-game about a specific concept can be used with children at school or with other students in a short course around any similar subject matter. Conceptual mini-games can be useful for different activities and with different social groups. Moreover, a conceptual mini-game for teaching a specific concept can be used in different subjects and contexts. For example, a conceptual mini-game about electric circuits can be used in a technology subject at school or in the context of a physics lessons. Therefore, a conceptual mini-game is developed with a specific aim, but it is possible to find other application fields. In other words, conceptual mini-games are highly reusable.

It is possible to develop conceptual mini-games to improve preschool children coordination, or to teach colours or numbers. This kind of mini-games is especially useful with children in school age because these children are more averse to study and have less motivation. But they still can have a large range of conceptual mini-games around their school subjects: maths, languages, science or even gymnastics by means of some of new user interfaces. The main advantage is that children are always ready to play.

There is a similar application for university students. Each subject can have a large collection of conceptual mini-games to use as exercises or even to drive classroom lessons. Furthermore, conceptual mini-games can be used in researching tasks as, for example, as research test-beds [3][7]. *The Experimental Gameplay Project* [8] has developed a great amount of mini-games that could serve as examples for our theories. The Experimental Gameplay Project is a project which was started by four students of the Entertainment Technology Center at the Carnegie Mellon University. Their aim was to discover new ways to play by means of developing prototypes very quickly. These students developed mini-games as proof of concept. Each mini-game was developed by only one person and during only one week. The results of this project are really interesting but should be taken into account carefully, because the aim of this project is to improve playability and conceptual mini-games aim to improve learning. There is something in common, though. Both projects find mini-games to be related to a specific concept.

Conceptual mini-games can be develop for individual use or for be grouped in a complex platform. The second option allows for join conceptual mini-games in lesson collections. Each conceptual mini-game is considered as a learning object, that is, a technological entity which is designed for education. The main idea is that educational materials can be divided by smaller pieces so these parts form didactic units if they are assembled [9]. It is possible to make complete systems with conceptual mini-games directed at the same subjects. This method allows students even to learn a complete subject practicing each concept individually using a specific conceptual mini-game. Furthermore, it is possible to develop conceptual mini-games platforms which constitute guided itineraries for learning. This fact makes the use for conceptual mini-games in education a powerful tool.

4. MEMOWL: AN EXPERIMENTAL EXAMPLE

At the moment of writing down this paper, a collection of conceptual mini-games is being developed by the University of Alicante. Our aim is to develop a group of this kind of conceptual mini-games about different contents for learning. To start over, we have produced a conceptual mini-game about a general matter: memory stimulation.

In this conceptual mini-game, called *MemOwl*, users practice with some exercises for memory development during a specific time and finally, they get information about their performance score. This conceptual mini-game has simple rules: players have to memorize some pictures during an instant and then, these pictures disappear (see Fig. 1.). A square where there was a picture will be shown (see Fig. 2.) and the user will have to pick up the exact image which previously filled this square from some given alternatives (see Fig. 3.).

(Fig. 1. First step in the MemOwl game. Player has to memorize the pictures during a moment)

(Fig. 2. Second step. When time for memorizing finishes, pictures disappear and a square is pointed. The picture that was in the square has to be selected from alternatives below.)

(Fig. 3. Third step. When an option is chosen, the result is showed. This result indicates if the answer is correct or not.)

This mini-game has all the characteristics that we include in our definition of conceptual mini-game for learning: It tries to teach or promote a specific concept, its rules are very easy to understand for users and it is endless, in the sense that there is no performance limit to be achieved by the user.

As long as the rules do not change along the game, it is necessary to create a mechanism for increasing the difficulty progressively. Measuring accurately the appropriate level of difficulty for each player is extremely important because it should increase personal effort in players, without overloading them, and it should also avoid their boredom. There are several levels in MemOwl to make the game more exciting. Players raise their level when they succeed in a certain number of games. However, they reduce their level if they make too many mistakes. Each level has its own specific characteristics:

- *Number of squares which appear in the screen for memorizing*. These squares could host a picture for memorizing or not and they could be present only for confusing. The number of squares increases according with level difficulty.
- *Number of pictures for memorizing*. It consists in the quantity of visible pictures in the squares which player have to memorize. The number of pictures increases according to the level difficulty too.
- *Time for memorizing*. Players have a short period of time to memorize pictures. This time decreases according with game level.
- *Number of alternative pictures for selecting the answer*. When time for memorizing ends, users have to choose the correct answer from the alternatives shown. Some pictures will be showed and the player must select one of them. When level increases, the number of these pictures increases too. At first, pictures for answering and pictures for memorizing are the same. However, other pictures with other colours will show during the game for confusing.
- *Number of good choices players need to increase their level*. Players will need more good choices for increasing their level in higher levels.
- *Number of bad choices which players need to decrease their level*. Players will need less bad choices for decreasing their level in higher levels.

Mainly, players want to make an effort for increasing their level because a good choice in highest levels scores more than a good choice in lowest levels. It is important to avoid that player had to start always from the same level, so levels are grouped in categories. Players can choose the category they want to start playing: low, medium or high. Furthermore, players can increase their level in each category. This fact is transparent for players and they only notice a difficulty increase. Figures 4, 5 and 6 show a random screenshot of each category for observing the differences between levels.
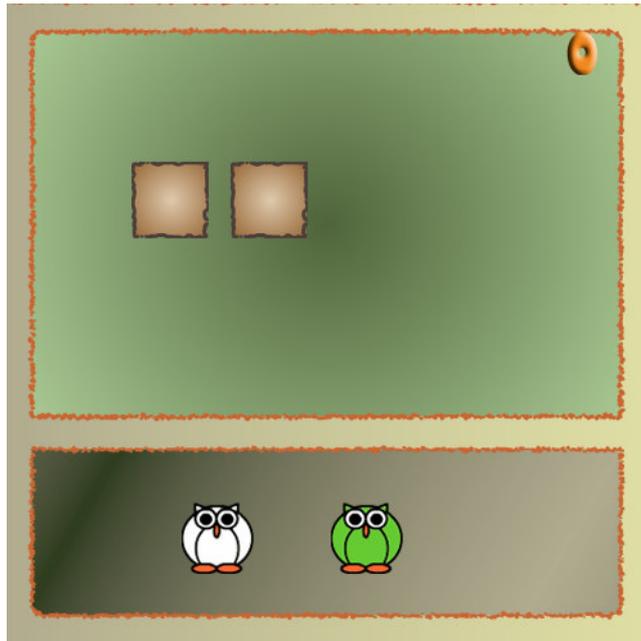
(Fig. 4. Initial level. There are few squares and few pictures for memorizing. Furthermore, there is the same number of pictures for memorizing than the ones for picking up an answer.)

(Fig. 5. Medium level. The number of squares and the number of alternatives fro picking up an answer are increasing. The number of pictures for memorizing and alternatives for answering could be different)
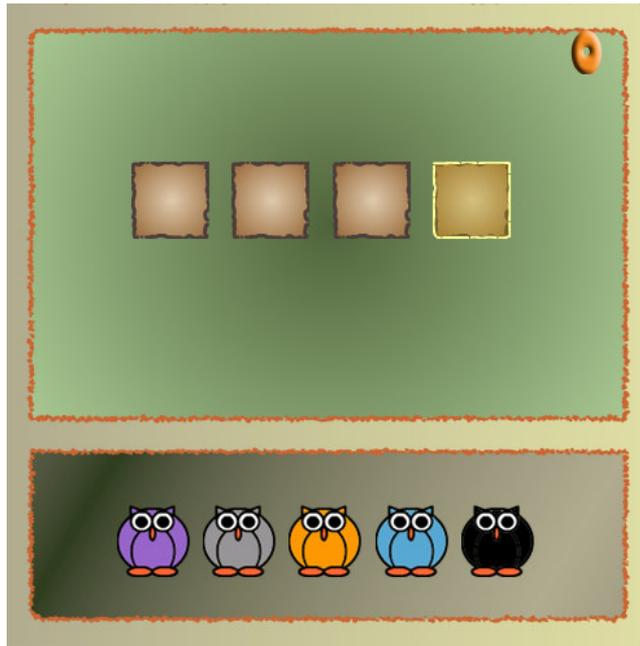
(Fig. 6. Higher level. The number of squares and pictures for memorizing are still increasing. The number of pictures for memorizing and for answering could be different)

MemOwl speeds up visual memory in the first place because players have to memorize the elements they see. Players have to pay attention to memorize and recognize these elements. Furthermore, MemOwl stimulates the short-term memory because this game consists in consecutive memorizing exercises so things which were memorized in a previous stage will be replaced with the next ones. In short, the type of memory which gets more exercised in this conceptual mini-game is the photographic memory. Players have to memorize visual elements in a short period of time. When players achieve higher levels, the period of time for memorizing decreases, so they have to use their photographic memory for solving the situation.

Regarding the development of MemOwl and its costs, it has been developed in C++ and using the Simple DirectMedia Layer library (SDL) [10] which provides basic functions for drawing 2D pictures and image management. Although this library also provides audio processing, sound effects and music have been developed using Audire library [11] because of ease of use and some reliability issues found. Each piece of software used to build MemOwl is free software released under GNU GPL or LGPL license.

MemOwl has been developed in one month, including programming, graphics and sound. The most costly work has been the automatic generation of game rounds. In this process, the squares, pictures for memorizing and pictures for answering are generated according to the game level. Each element must be in their correct place and in their correct time according to the game state.

This is a conceptual mini-game for memory development so its application fields are very wide. MemOwl is easy-to-understand and easy-to-play, so it can be applied to a lot of social areas and players can be from distinct ranges of ages, from little children to old people. For this reason, this conceptual mini-game can be in education programmes for children and in mind development courses for old people, as well as all the intermediate age stages. Furthermore, MemOwl can be used in different fields because memory usage is very common and is not restricted to specific fields.

MemOwl is the first of a varied collection of conceptual mini-games about concepts coming from subjects of different university degrees: teaching, philology, sciences, architecture, engineering… Furthermore, the final idea is to develop a platform where to group all these conceptual mini-games. Students will always be able to find conceptual mini-games appropriated for their studies. A prototype for this environment is also being developed at the University of Alicante at the moment of writing down this paper.

5. CONCLUSIONS AND FUTURE WORK

In this paper we have discussed about computer games and their use in education. Nowadays, there are a lot of technological advances regarding computer games and teaching can be one of the most favoured areas. The present challenge is to find the appropriated kind of games for teaching each concrete concept we wanted to teach.

Mini-games present several advantages with respect to large computer games. In this paper we have defined a specific kind of mini-games which we have called Conceptual mini-games. Conceptual mini-games are entertainment units appointed to teach a specific concept. This kind of mini-games is easy to develop so it is possible to get rid of the costs of developing large computer games and, moreover, to create lots of them aimed to teach different topics. Furthermore, thanks to their high reusability, they can be grouped to form didactic units.

The University of Alicante is studying the use of conceptual mini-games as different subject materials. For this study, we have developed a first conceptual mini-game. This conceptual mini-game, called MemOwl, is focused on memory development. MemOwl has been shown as an example of conceptual mini-game having all the characteristics we find interesting for these serious mini-games.

We still had not have time to drive experiments with MemOwl, but only to plan them for the next step in our research. It is necessary conduct several experiments to check the effectiveness of our conceptual mini-game. This activity will consist in choosing two groups of people with similar academic characteristics. One of these groups will play MemOwl during few weeks and the other one will not. At the end of this phase, both groups will realize a memory test and the results will be analyzed. We expect that people playing MemOwl will increase their visual memory and their short-term memory more than people not playing.

References

[1] Marc Prensky. *Don't Bother Me Mom – I'm Learning!* Paragon House. March 2006 ISBN: 1557788588

[2] Sara de Freitas. Learning in Immersive worlds. A review of game-based learning. Prepared for the JISC e-Learning Programme. JISC (Joint Information Systems Committee) (Available Online 15/01/08)
http://www.jisc.ac.uk/media/documents/programmes/elearninginnovation/gamingreport_v3.pdf

[3] Francisco Gallego, Rosana Satorre, Faraón Llorens. *Computer Games tell, show, involve… and teach.* SIIE (Simposium on Computer in Education) Vol. 1. October 2006

[4] European University of Madrid in collaboration with the Computer Game and Animation Observatory. *Influencia del videojuego en la conducta de los usuarios y habilidades que desarrolla en los mismos.* Published by aDeSe (Asociación Española de Distribuidores y Editores de Software de Entretenimiento) (Available Online 07/06/07) http://www.adese.es. Diciembre de 2005

[5] Yearbook aDeSe 2006 (Asociación Española de Distribuidores y Editores de Software de Entretenimiento. (Available Online 15/01/08) http://www.adese.es/pdf/anuario-memoria-2006.pdf

[6] Paul Angiolillo. *Gaming Makes the Grade.* MIT Technology Review. (Available Online 15/01/08) http://www.technologyreview.com/Infotech/14791/. September 2005

[7] *Francisco Gallego, Faraón Llorens, Mar Pujol, Ramón Rizo. Driving-Bots with a Neuroevolved Brain: Screaming Racers. Inteligencia Artificial. Revista Iberoamericana de Inteligencia Artificial. Invierno 2005, Volumen 9, Nº28 ISSN: 1137-3601*

[8] Experimental Gameplay Project (Available Online 15/01/08) http://www.experimentalgameplay.com/

[9] Wiley D. Connecting learning objects to instructional design theory: A definition, and a taxonomy. The Instructional Use of Learning Objects. (Available Online 15/01/08) http://reusability.org/read/chapters/wiley.doc

[10] SDL Simple DirectMedia Layer (Available Online 15/01/08) http://www.libsdl.org/

[11] Audiere (Available Online 15/01/08) http://audiere.sourceforge.net/