Evolutionary Videogames for Personalized Special Education

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Abstract
Videogames can be ideal learning tools for special education since they provide training skills, promote independence, and increase and improve students' concentration and attention; in addition, new knowledge can be easily acquired and exercises carried out successfully. Our work focuses on designing personalized games that can be adapted to each user's cognitive level and characteristics, and that can evolve with the user according to his/her progress. The use of adaptation techniques in software development process includes user analysis in the early development stages in order to get a better personalization for each potential game user. We therefore propose different personalization levels, each one at a different development process phase.
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1 Introduction

The use and development of technical tools to help people with speech and communication disabilities (autism, cerebral palsy, ictus, dysphasia, etc.) is a challenge for our society since these tools offer the prospects of social and labour integration, rehabilitation and independence.

The main learning difficulties of people with special educational needs are due to their cognitive limitations or disinterest in the subject. A new method of alternative learning must therefore be used which offers mechanisms to stimulate them, to increase their attention and concentration, and focus on the children's cognitive virtues and freeing them from the pressure of the traditional learning process.

Videogames are a direct, attractive platform for getting closer to children with disabilities, as not only do they offer new forms of human-computer and student-student interaction, but they also promote special education learning. Videogames enable knowledge to be developed through game contents and cognitive abilities are increased through play. Some studies [1] [2] have demonstrated that the use of videogames in the learning process provides the following benefits: improvement of cognitive abilities through creativity and discovery, increase in attention and concentration, stimulation of the learning process and attendance, improvement in communication, and academic success.

To date, there have been very few learning videogames for special education, and most of the ones that do exist tend to be difficult to access or to consist solely of teaching units with no game element. Computers continue to be the most used games platform rather than others with larger interaction and multimedia capabilities, and this

is mainly because the driving force behind videogame companies is profitability and this would be reduced if they were to develop special and personalized games for small groups of people with different needs.

It is essential for special education to be tailored to each individual child, considering their skills and capacities, and each child must learn at their own rate of work. At the same time, the child's integration must be improved, helping him to communicate with his fellow pupils and teachers. We have therefore been inspired to design videogames for learning and communicating that can be personalized to each child and which can evolve as the child progresses with the game.

The second section of this paper presents various considerations about special education and videogames. Section 3 shows our method and process for creating personalized videogames. Finally, Section 4 outlines our conclusions and future lines of work.

2 Considerations about Special Education and Videogames

Learning with special education games is based on psychopedagogical mechanisms. The game must be easy to personalize and it must allow different forms of interaction, avoiding discrimination as a result of the player's cognitive characteristics.

Gardner [3] proposes the "Multiple Intelligences" theory which states that intelligence is not unique or indivisible, but can be considered as a set of abilities that can be trained. The training can be carried out using educational videogames. A person with autism, for example, is limited in his intrapersonal/interpersonal intelligence, but his logical, spatial or musical intelligences can be stimulated using a game so that his sensations, emotions or meditations can be expressed by means of association between symbols and meanings.

Sidman's theories [4] of "Equivalence relationships" and "Stimulus Equivalence" can also be applied to the design of videogames for special education. By training explicit relationships between stimuli, new implicit relationships appear which enable the pupil to learn to relate concepts with their representation using pictographic symbols, written words or sounds.

The following factors must be taken into account when designing videogames for disabled people [5]:

- The player's cognitive limitations must be considered in order to choose suitable stimuli and interactions. The disability must not be the cause of frustration. If errors are made, they must be corrected without causing despondency.
- The educational contents must be hidden in the game structure. It must only be necessary for the player to concentrate on the game, so that learning is implicit.
- A main hero or heroine, who the child identifies with, can act as a guide by winning the child's confidence.
- The learning process must be incremental, based on steps or missions with increasing levels of difficulty, taking into account the child's cognitive level. All of the game's objectives must be clear.

- Rewards must be granted when specific actions in the game are carried out: songs, videos, points or real objects. This stimulates the child to continue playing and therefore learning.
- The mechanisms used to carry out an action in the game must be the same as the mechanisms used in the real world to perform the same action.

As we have mentioned previously, in order to personalize the videogame to a special needs player, it is important to obtain information from their user profile. The user profile compiles data about cognitive capabilities and ways of solving the player's disabilities (problems of vision, hearing or mobility). Some of the aspects to be considered are:

- Use of dialogues and subtitles.
- Personalization of the type, color and size of the text for titles, menus, etc, increasing the contrast with the background. Possibility of selecting a colored template specifically for the game.
- Use of voice to present contents. Possibility of selecting the frequency and volume of the sounds.
- Alternative navigation using voice recognition.
- Use of adapted devices or personalization of controls (e.g. keyboard, mouse, touchpad, etc.).
- Flexibility in game precision to enable dynamic adaptation to the user when he wants to select someone.
- Possibility of adjusting the difficulty of the game, providing different levels.
- Indication of the platform on which the game will be played, including the case where the number of screens can also be selected. This enables the distribution and feedback of the contents to be organized.
- Possibility of selecting the game characters or other multimedia elements, e.g. specific music or images.
- Selection of the size of the images or videos. This also involves redistribution of the contents.
- Indication of where specific stimuli or reinforcements will be used in the game and what they are (sounds, video, points, etc.).
- Ways of evaluating each player's progress.

3 Our Proposal for Adaptive and Educational Videogames

Our proposal arises from the alternative and augmentative communication system Sc@ut [6] which was developed by our research group. Sc@ut is a platform which enables the creation and evolution of communicators based on a hypermedia net with images, sounds and links. Sc@ut communicators are adapted to each user and run on Pocket PCs or computers. Communicators can also be used as teaching units in which the user can select the concepts requested by the teacher, concepts which have

previously been programmed by the teacher to appear in the system. Due to the limitations of the Sc@ut communicator, we cannot achieve the same learning advantages as we can with videogames.

We therefore searched for a new platform to play the educational videogames and we selected Nintendo DS™ for the following reasons [7]:

- It is small, portable, known by the children, very attractive and resistant because it was designed for children.
- It has two screens, one of which is a touch screen to increase interaction possibilities and enables visual reinforcements to be given with large multimedia capabilities (sound, video, graphics, etc.) and without any apparent memory limitations.
- It is a device for games with 11 hours of autonomy.
- It has Wi-Fi connection to communicate with other consoles or PCs.
- It is cheap and costs less than a Pocket PC.

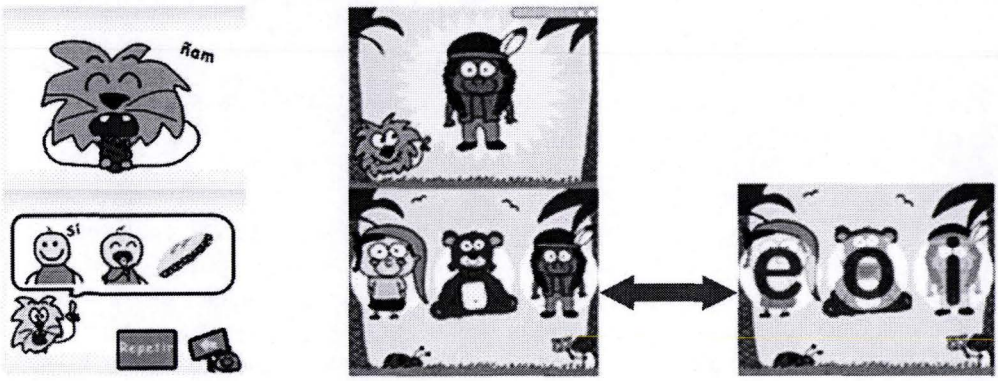

Fig. 1. Two different examples using our proposal for educational personalized videogames

The objective of the games that we propose is to teach various concepts. The game comprises different stages (phases), each of which trains a different concept, and each stage is further divided into levels which describe an exercise for training concepts, incorporating new concepts that act as distracters. The positive and negative stimuli or reinforcements, and the goal that must be reached in order to proceed to a higher level are also defined in each level.

Fig. 1 shows two games designed by us, running in the Nintendo DS™ console. The left one helps to create easy sentences using pictograms: "I want to eat a sandwich", in the example. The right one is a videogame with heroes used to teaching the vowels in Spanish.

We have designed a platform to create and modify these adaptive games, which is based on the two-layer structure of the Sc@ut architecture. The platform structure consists on three layers: the meta-game, the meta-phase and the meta-level.

Correspondingly, the responsibilities of each layer are:

- *Meta-game*: It considers two dimensions in keeping with the user profile: a*ccessibility* and *gameplay*. Accessibility describes the User's Interface to each child taking into account the player's skill profile and disabilities to offer alternative presentations of concepts or interaction methods. Gameplay defines the objectives and educational contents to be taught in the full game. A main character or hero is used in the game, who acts as a guide in the learning process. Each game must have goals. The learning process should be in rise, based on multi-levels or missions where the level of difficulty increases gradually. For each right action, a reward is obtained: animations, songs, videos, points, objects, and even, gifts in the real world.

- *Meta-phase*: The game can consist in different stages, each one with different objectives and that use different concepts. This level involves displaying the concepts to be selected and the multimedia contents that represent the concepts. They must be suitable for the child given his/her user profile. The game design definition is carried out at a conceptual level, therefore the multimedia elements can be changed without changing the concept to be represented, because it only define what we need to show and not how it will be shown.

- *Meta-level*: Used to define the exercises for training concepts. A variety of exercises must be proposed to be instantiated with each concept being trained (with the inclusion of distractors). These exercises are based on equivalence relationships, e.g. associations or puzzles with pictures of the concept, which the user must construct by following a pattern, or asking the child to search an identical pattern to the one presented from a set of images which include distractors. Several stimuli, reinforcements and different ways of completing the various levels must be available so that the teacher can configure the game.

Table 1 shows the aspects that can be modified in each layer. The meta-game, meta-phase and meta-level must be prepared to anticipate the instantiation that the educators are going to perform for one concrete user using the platform. Table 1 also shows the example of instantiation of these aspects for our vowels game.

Table 1. Videogames platform structure and instantiation of a game

Layers	Adaptable Aspects		Instance: Vowels Game
Meta-Game (Engine and IU Options)	ACCESIBILITY	Subtitles	No
		Dialogues	Yes
		Alternative Navigation	Voice Recognition
		Colors Palette	Black/White
		Images Size	Normal
	GAMEPLAY	Hero	Leoncio, The Lion
		Feedback	Music and Text
		Interaction	Stylus
		Difficulty	Normal
		Objective	Teaching Vowels
		Context	Adventures
		Nº Phases	5
		Initial Phase	Drawing a vertical line
Meta-Phase (Concepts to be taught)	Objectives		Learn "I" letter
	List of Concepts		I letter, Indian
	Multimedia contents of the concepts		"I" sound, Indian Sprite
	Intro		"I" Island
	Ending		Indian Playing
Meta-Level (Exercises to learn into a games structure)	Kind of Exercise		Stimulus Equivalence, association of images
	Stimulus		Sound/Images
	Positive Reinforcement		Sound: "Very Well!, this is a "I" letter and Indian start with "I" Video: "Very Well"
	Negative Reinforcement		Sound: "This letter isn't right. Don't worry, try it other time!" Video: "Don't Worry"
	Distractors		"A", "E", "O"
	Transparency level		Medium.
	Objetive		Searching a patter with the pictogram Indian and letter I
	Order		Random

To develop a videogame, a software development process is followed. Traditionally, adaptation has been performed in the design graphic level of the user interface but it is not enough. During the first development phases, the modelling of the user must be carried out and it have to be taken into account in the next phases to perform a best adaptation and personalization [9, 10].

Our objective is creating a tool useful for designing videogames adapted to different users with different profiles. In order to that, we propose four adaptation levels with different abstraction: functional, representation, visualization and contextual. The relationship between the meta-layers and these adaptation levels during the development of the game can be shown in the figure 2. This figure also shows two games designed with the tool.

The description of each level is:

- *Functional*: The user profile is configured. It consist in describe the abilities, capabilities, limitations, concrete needs and objectives from and for the user. The cognitive level, experience in the game, knowledge about the game domain, security and access level to the functionality of the game are analysed. Taking into account the full specification of the game, different views and filters are specified.

- *Representation*: This level defines the conceptual level of the design of the user interface. Elements and controls used are defined depending on the user profile (specially his cognitive level, motoric and sensorial capabilities), his experience and the way of interacting to the system. Different concrete helps for interaction are specified, as lists or bottoms to avoid the user to write if he has difficulties, decreasing also the error risk. The user can be guided during the interaction lowering the cognitive charge necessary to play.

- *Visualization*: It possibilities the adaptation in the design phase. Different user interfaces are designed for different users, from the previous specifications. Decisions are taken about concrete elements that must appear in the user interface, their position, synchronization and temporal relationship. Different styles are designed for different users from the style guides defined in the specification. For example, for a person with low vision, concrete colours that can be viewed by him are selected. The same with the size of the interface elements (for example, the font). Sonorous information can be also added to some elements to help the interaction.

- *Contextual*: This level is in charge of the adaptation at run time because the game must answer to the stimulus from the user environment. Factors as localization, time or activity that the user is doing influence the game. Depending on the time and the place where the user is, a different task in the game could be carried out. Besides, the previous interaction of the user

during the game affects to the following interactions. For example, a high punctuation reached in a phase of the game will increase the experience level of the player and will allow that the next time the exercises to be carried out were more difficult.

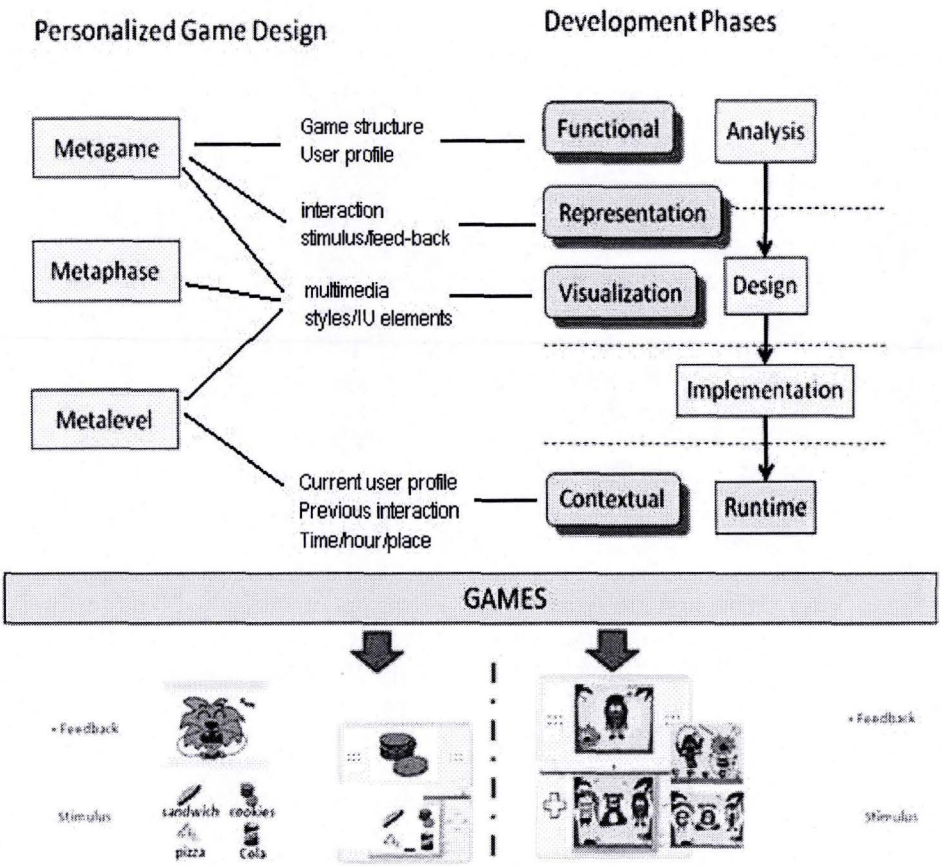

Fig. 2. Videogames creation schema

4. Conclusions and Future Work

In this paper, we have presented the possibility of creating videogames which are personalized to people with learning disabilities and which can be adapted to suit the user characteristics and adjusted to the user's cognitive level according to his/her progress.

We have proposed the design of a platform to develop videogames taking into account their adaptation during all phases of the lifecycle of the software. This platform can anticipate the characteristics of the game depending on the user profile, way of interaction, contextual information and multimedia used.

To date, we have implemented a videogame for learning the vowels on the Nintendo DS. We have tested the possibility of changing the multimedia used in the game and configuring specific aspects of the user profile (e.g. the stimuli or the scoring for the different levels). While we have not encountered any problems at the design level of adaptive and adaptable videogames thanks to our experience in the design of evolutionary systems, we are encountering problems when it comes to implementing the games because of the limitation of the languages and platforms on which they can be supported. We will therefore continue to search for alternatives in order to achieve our objectives of implementing adaptive games so that they can be used by teachers and pupils with special needs.

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