

ADAPTIVE COMPUTER GAMES FOR SECOND LANGUAGE LEARNING IN EARLY CHILDHOOD

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ABSTRACT

Children at L2 primary levels acquire knowledge and language skills associated with different abilities through educational games. The game introduces learning activities by using playful elements as a source of motivation. The success of the game depends on an optimum relationship between challenge, fantasy, curiosity and control. This is also applied to educational computer games. Moreover, if these games contain features which have the capacity to adapt the instructional presentation dynamically according to the characteristics of a particular student's progress, these are referred to as adaptive computer games.

In this sense, the web-based adaptive hypermedia system SHAIEx makes the individualized learning of English at early ages possible by means of adaptive computer based educational games. In the process of generating interactive games, the child chooses a game from the set of games that SHAIEx has described as appropriate for his/her educational level and domain of knowledge. The client side of SHAIEx sends both the child's identification and the identification of the selected game to the server side, which in turn selects the most appropriate multimedia elements (graphics and audio) in the content database. These elements, which are associated to the game according to the child's characteristics -the educational level and the psychomotor skills captured in the mouse interaction style-, are adapted by SHAIEx.

In this contribution we describe the architecture that makes both content and presentation adaptation feasible, and we present how SHAIEx dynamically creates educational games considering the child's characteristics. Likewise, we show the process of generating several educational adaptive games (Choose, Body Identification, Stickers, etc.) by modifying their difficulty, mouse interaction style and the content according to a particular student's features.

1. Introduction

These days children of all ages live in a media-rich environment and interact with a diverse range of electronic devices both inside and outside their homes. They are part of each child's world and have the potential to provide even very young children with opportunities for new forms of creativity, communication and collaboration that are not dependent upon mastery of the spoken and written word.

Children's access to computers and the Internet at school has become rapidly prevalent in recent years. However, the potential value of a personal computer in early child development has been vigorously debated among parents, teachers, and researchers for decades (National Association for the Education of Young Children

[NAEYC], 1996; Goodwin, Goodwin & Garel, 1986; Haugland & Wright, 1997; Scoter, Ellis & Railsback, 2001; Cordes & Miller, 2000; Kemp, 2002). Although a number of child developmental theories have been used in the literature to speculate whether (or how) the computer would affect early childhood (either positively or negatively) (Brady & Hill, 1984; Elkind, 1987; Clements, Nastasi & Swaminathan, 1993; Schetz & Stremmel, 1994), the empirical evidence is scarce and conflicting. A number of studies found no effect of computer use on children's knowledge of pre-reading concepts (Goodwin, Goodwin, Nansel, & Helm, 1986), discourse skill (Schetz, 1994), and/or cognitive development (Clements & Gullo, 1984; Howell, Scott & Diamond, 1987; Lehrer, Harckham, Archer & Pruzek, 1986). Some authors have argued that computers are too abstract or too symbolic for the developmental stage of preschool or younger children. The arguments include the notion that computers might replace some early childhood activities that are essential experiences to children's physical, psychological, and social development (e.g., playing with tangible toys and interacting with peers) (Cordes & Miller, 2000; Brady & Hill, 1984; Elkind, 1987; Barnes & Hill, 1983). In contrast, several studies have found that computer use enhances children's fine motor skills (Ziajka, 1983), alphabet recognition (Williams, 1984), concept learning (Grover, 1986), numerical recognition (McCollister, Burts, Wright & Hildreth, 1986), counting skills and pre-mathematical knowledge (Howard, Eatson, Brinkley & Ingels-Young, 1994; Clements, 2002), cognitive development (Clements et al., 1993; Clements, 1994; Sivin-Kachala & Bialo, 1994; Shute & Miksad, 1997) and self-esteem or self-concept (Sivin-Kachala & Bialo, 1994; Haugland, 1992).

Although the personal computer is now the most used resource in the preschool classroom, ICT in Early Learning is much more than this. Highly innovative work (Hoppe, 2006; Geronimo-Castillo & Sturm, 2006) is being carried out using programmable toys, floor robots, digital cameras, scanners, mobile telephones, cassette recorders and video recorders.

Playing games to learn basic life skills has been an important learning strategy from the earliest times, and remains so today, especially for early instruction at home. Preschool children acquire learning, approaches and skills associated with different abilities through educational games. The game introduces learning activities by using playful elements as a source of motivation. The success of the game depends on an optimum relationship between challenge, fantasy, curiosity and control (Malone, 1981; Malone & Lepper, 1987). This is also applied to computer-controlled games where a video display such as a monitor or television is the primary feedback device. They are seductive, deploying rich visual and spatial aesthetics that draw players into fantasy worlds that seem very real on their own terms, exciting awe and pleasure. The fact is that, for children and youth, computer games "are the most frequently used interactive media" (Beentjes, Koolstra, Marseille, & van der Voort, 2001).

Educational computer games motivate via fun ('part of the natural learning process in human development'), via challenge and instant, visual feedback within a complete, interactive virtual playing environment, whereby ambience information creates an immersive experience, sustaining interest in the game. To encourage development they should allow the children to choose and to control the activity they want to develop. There are higher levels of creativity in children that use games whose structure is less rigid, i.e. facilitating free choice (Johnson, 1985). Also, children show greater interest in computer games that respond in real time to their interactions

(Escobedo & Bharoava, 1991). The multimedia content that combines in an effective way the audio, the text and the images (static as well as dynamic) can stimulate the children's learning and keep their attention during long periods of time (Liu, 1996). In this stage where they have not yet acquired reading and writing skills, the audio presentation of the instructions to complete the activities is very important.

If the educational computer game has the capacity to adapt the instructional presentation dynamically according to the characteristics of a particular student and his/her progress, it is called an adaptive game. This kind of game offers personalized learning experiences to preschool children. Dynamically generated educational games compose the visible user interface of SHAIEX (Agudo, Sánchez, & Sosa, 2005), a web-based adaptive hypermedia system whose aim is to complement the learning of English as second language in Preschool Education. SHAIEx adapts both the content and the navigation according to young learners' characteristics.

2. What is an Adaptive Hypermedia System?

The hypermedia is developed as a result of linking two technologies: multimedia and hypertext. A computerized multimedia application involves different audiovisual means to represent the information (e.g. text, images, sound and video). The hypertext, on the other hand, consists of a series of text blocks connected or linked among themselves in a way that users can pass from one block to another in the order they wish and according to the user's needs, interests and/or point of view. Consequently, the hypermedia allows us to structure the information in a non sequential way and that information can integrate different means (i.e. text, graphics, sound and video). The hypermedia benefits in the learning process are unquestionable. On the one hand, it enables the student to freely explore the knowledge depending on their necessities and goals. On the other hand, the information is transmitted by using different sensory channels, important in the didactic process. However, in these systems the student can freely explore the knowledge (information) appropriate or not to the student's cognitive level.

Intelligent tutoring systems (ITS) are computerized systems designed to teach knowledge in a subject. An ITS presents the student a problem whose level of difficulty is appropriate to the student skills. The ITS compares the student solution with the correct solution registered, and then, informs the student of the result. The student skill model is updated and presents a new problem once and again. The ITS are interesting because depending on the student's response it modifies in an automatic way its proposal to adapt to the learning speed and the detected knowledge level. However, they are highly instructive systems where the student has little or no control over the learning process.

The integration of an intelligent tutoring system in a hypermedia system originates an adaptive hypermedia system (AHS) (Brusilovsky, 1998; Brusilovsky, 2001). The AHS profits from both systems: the tutoring part takes advantage of the flexibility and use of different audiovisual methods that the hypermedia part provides. And the latter one benefits from the adaptation to the student so that the tutor performs as a more customized educational system.

In this sense, the web-based adaptive hypermedia system of SHAIEx makes the individualized learning of English at early ages possible. Thanks to its hypertextual structure and multi-sensorial richness, children can develop their innate curiosity and complete the educational activities / games they wish as soon as they are adapted to their level.

3. SHAIEx: An Adaptive Hypermedia System for learning English in Pre-school

In this section we describe the architecture that makes possible both content and presentation adaptation and we present how SHAIEx creates dynamically educational games by modifying their difficulty, mouse interaction style and the content according to a particular student's features. Likewise, we illustrate several educational adaptive games (Choose, Body Identification, Stickers and others) that compose the didactic units of SHAIEx.

3.1 Web-based architecture

SHAIEx has a distributed, three-layered architecture. This type of architecture is an enhancement of the traditional two-level client / server architecture. Just like in such a conventional type, the three layered architecture separates user interface from business logic (programming) by distinguishing access to information from business (working with a database).

We have developed a web-based system that presents the information to the user with Macromedia Flash (User Interface) and provides the adaptation in the server by means of Java Servlets that decide the best task for the student (Intelligent Tutor). The Intelligent Tutor is divided into four parts (Figure 1): Navigation Control, Task and Rules management, Student management and Content management. The Navigation Control allows connecting User interface with the Intelligent Tutor. The Task and Rules management consults the task and rules database in order to decide (according to the rules) the next task to do. The Student management handles the user model that stores the student's characteristics. Lastly, the Content management builds the next activity by consulting the pedagogic domain that stores the information on each task.

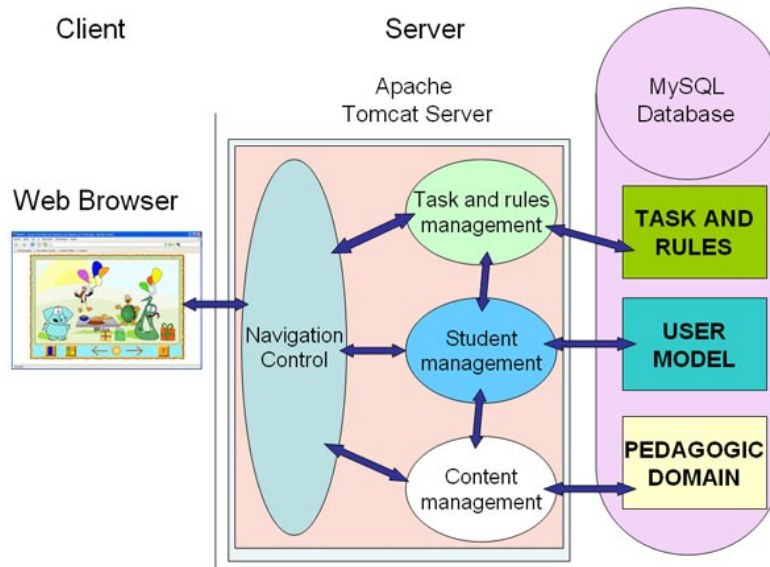


Figure 1: SHAIEX Architecture

3.2. Adaptation Parameters

The characteristics which compose the user model of SHAIEx and will adapt educational video games to preschool learners are determined by the educational level which refers to the child's knowledge regarding the domain of knowledge, the psychomotor skills captured through the observation of the interaction style with the mouse, the native language and the acquired knowledge. Since pre-reading and pre-writing stages emphasize educational input such as visuals, listening, and gestures, learning styles should differ significantly at these early stages. Because multimedia activities, which combine video, sound, text, animation and graphics to stimulate different senses, are addressed to heterogeneous groups of students, such tasks should be developed by accounting for all students' needs and preferences. The three-tier architecture of SHAIEx keeps the structure and the multimedia components that compose the pedagogical domain (hyperspace) independent. This fact allows extending the user's model with more parameters of adaptation.

We have distinguished three educational levels according to pre-school curricula: level 1, involving a conceptual phase addressed to three year old children, level 2, corresponding to four year olds, and level 3, addressed to five year olds. In terms of knowledge, both the initial mental capacity and his/her progress with the use of the system are considered. Advancement is recorded in the user model so that the system can adapt to the child's progress.

Whereas many children are proficient in their interactions with computers, and some others have even adapted to electronic game interfaces, this condition is not easily applicable for all learners. As SHAIEx computer games must be accessible to all students, the system will adapt the young user's mouse interaction style to the psychomotor skills of the child.

These adaptation parameters affect the content of a video game. Being the same game for each educational level built in runtime from the same template, the multimedia elements that comprise each game adapt to the child's educational level in terms of

vocabulary, linguistic concepts and content, enabling the most appropriate multimedia element to be loaded from the SHAIEx content database. As these games are interactive, the mouse interaction style will be accommodated to the psychomotor skills of the child. In the first prototype of SHAIEx, the mouse interaction style is linked to the educational level, which means that specific psycho-motor skills are assumed for all children in each level. In future developments, SHAIEx will evaluate the learning activities of each child and his/her psychomotor skills independently when using the mouse, computer interaction which can be assessed by examining the speed at which children execute the operation, the number of mistakes they make and how comfortable children feel while using the mouse (Donker & Reitsma, 2005).

3.3. Pedagogical Domain and Adaptation Mechanism

The pedagogical domain consists of seven didactic units and comprises points of interest for pre-schoolers: hello, the body, home, the family, toys, food, and school. Each didactic unit includes four blocks of activities: presentation, interaction, evaluation and review. The first block is aimed at familiarizing learners with word association and vocabulary acquisition by interactive means. The second block is designed to consolidate concepts and linguistic content by means of interactive games. The third part evaluates acquired knowledge. Lastly, the fourth block reviews the didactic unit according to the student's results. The teaching blocks are orderly presented to the user according to specific teaching rules. So, before accessing the evaluation section, input and interaction blocks should have been successfully achieved. Each block includes one or more activity scenes which are educational games that children must complete and/or pass. The educational level and the acquired knowledge determine the following task to be faced.

The child selects a didactic unit by clicking on the associated icon (Figure 2). SHAIEx automatically searches for activity scenes of the selected unit according to his/her educational level and whose pre-requisites have been satisfied by the newly acquired knowledge. A transition scene is dynamically generated and presented to the child. This type of scene contains graphical, audible and clickable icons showing links to the next activities that the child could carry out.



Figure 2. Didactic units menu

When the child selects an educational activity, the intelligent tutor looks up the corresponding user model to determine how to mount the activity and with which multimedia elements. With this information the intelligent tutor builds a configuration file. This file is sent to the student host and the browser loads the adaptable Macromedia Flash game template and the multimedia elements, then, dynamically builds the most suitable activity for this particular student (Figure 3).

The configuration file is a XML document that stores the specific values for each adaptation parameter. By means of this file we can decide: content (educational objectives), language, difficulty, mouse interaction style (double click, drag & drop, one click, etc.) and finally, if textual information must be shown or not.

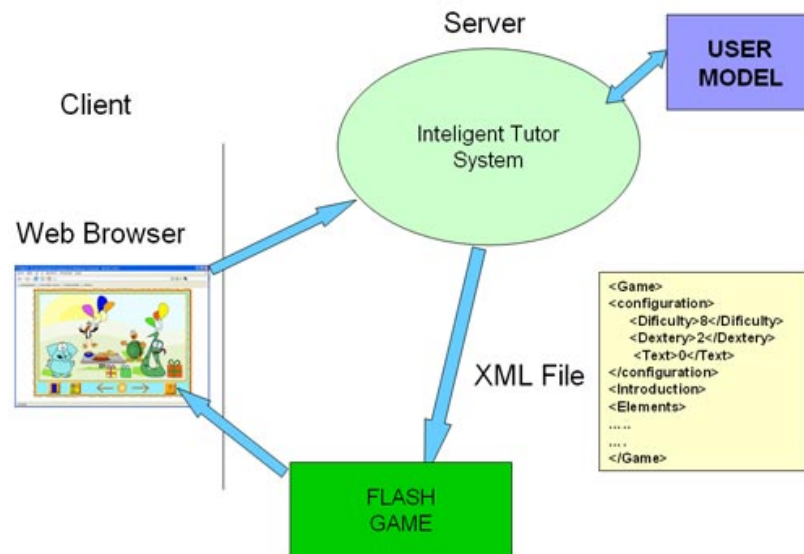


Figure 3. Game adaptation mechanism

In the activity shown in Figure 4, the child is asked to place the character in the corresponding silhouette after listening to information and descriptive hints. Likewise, the adaptation will be carried out according to five parameters: the number of characters (difficulty), the audio information related to each character (language and level), to show the text information or not, and the mouse interaction style.

	Level 1	Level 2	Level 3
Mouse interaction style	One Click	Click move click	Drag and drop
Objetives	Identify Characters	Identify Animals	Identify Countries
Number of elements (difficulty)	3	4	5
Language	English	English	English
Text information	No	No	Si

The screenshot shows a game interface with a light blue background. On the left, there are three green silhouettes of characters. On the right, there is a vertical pink bar containing five colorful cartoon characters. At the bottom, there is a navigation bar with a left arrow, a yellow circle, and a right arrow.

Figure 4: Adaptive game

The audio attached to each character depends on the language and educational level he/she has. For level 1 the character's name will be identified; for level two the animal type will be chosen, and for level 3, the information to be identified is the character's origin. The textual information only appears for level 3. Finally, the way of carrying out the activity for each level of dexterity with the mouse will be also adapted (one click, click move click, drag and drop).

When the child finishes up an activity, the information is registered and evaluated by the system. This assessment updates the user model, enabling the child to complete educational activities which adapt to the newly acquired knowledge.

3.4. Games in SHAIEx

Nowadays we are developing several educational adaptive games (Choose, Body Identification, Stickers, Counting, Matching, Colouring among others). These games are configurable and adaptable to the difficulty, interaction style and educational level corresponding to a particular child.

In the “Choose” activity (Figure 5), several objects (characters, things, animals etc.) appear and the child listens to the name of one object. Then she/he must select the corresponding object representing the sound heard.

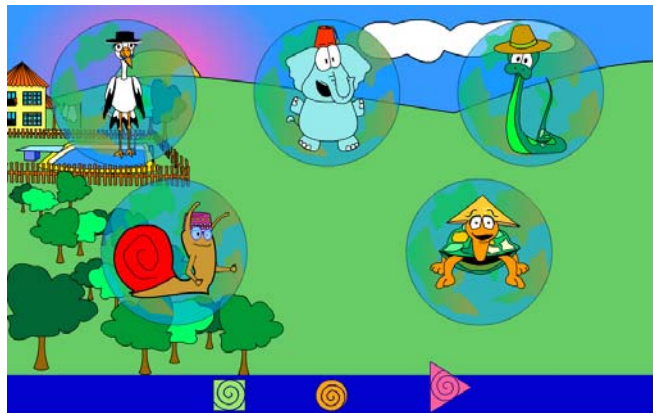


Figure 5. Choose activity

In the “body identification” activity (Figure 6) a character appears on the left of the scene with several parts of its body blocked out in grey, and on the right, the parts of the body that the child must position in the holes are shown. A sound determines which part of the body goes first.



Figure 6. Body identification activity

In the “stickers activity” (Figure 7) the child must place the objects in the corresponding silhouettes.

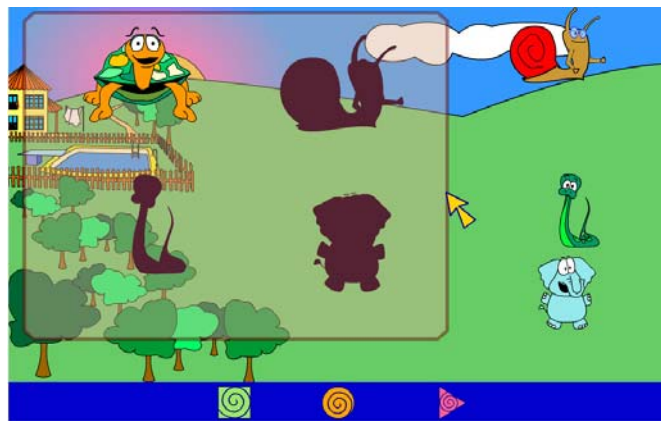


Figure 7. Stickers activity

In the “counting” activity (Figure 8) the student must count the objects that appear on the screen. A sound determines the type of object to be counted.

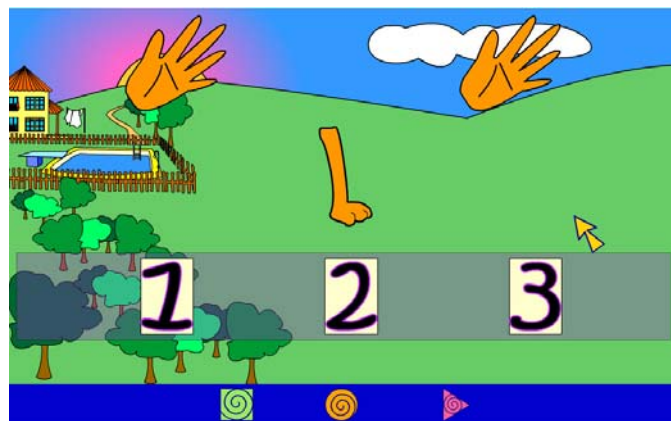


Figure 8. Counting activity

In the “matching” activity (Figure 9) the children must find all the matching pairs of objects (characters, things, animals etc.).

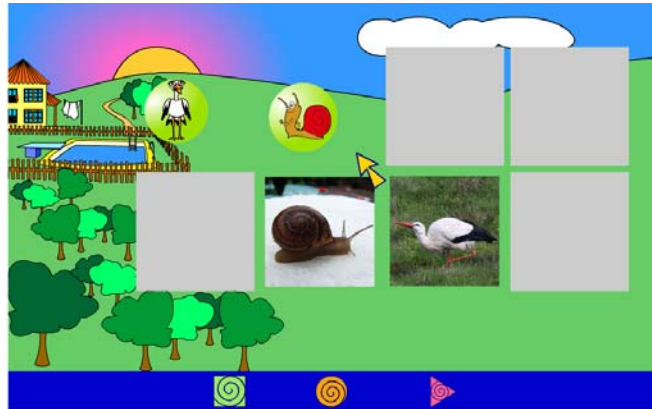


Figure 9. Matching activity

In the “colouring” activity (Figure 10) an uncoloured picture and a palette of colours appear. The child must click on a part of the body and listen for the name of a colour. He/she then chooses the colour on the palette and proceeds to colour the part of the body on the easel.

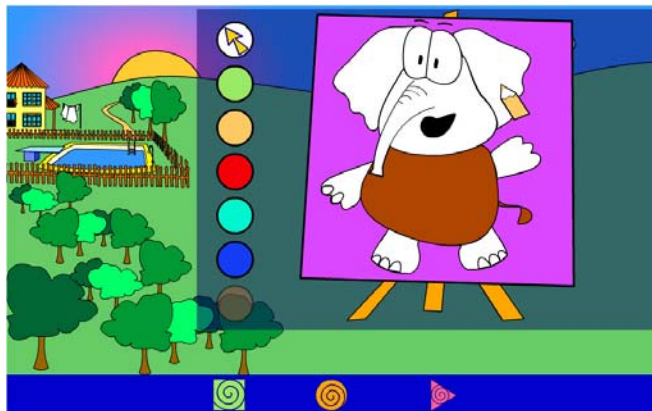


Figure 10. Colouring activity

When the child gets an option right or wrong in the games, he/she respectively receives a positive splash of confetti, or on the contrary, a negative squashed tomato (Figure 11) as feedback from the games to motivate and capture his/her attention in a fun way.



Figure 11. Left: Positive feedback, Right: Negative Feedback in SHAIEx games.

4. Conclusion

Most of the adaptive systems base their user interface in textual information because they are addressed to adult users. In our case, the users are children (3 to 5 year olds). At this early age, children have not yet acquired reading and/or writing skills, so the multimedia content plays a leading role, and adapting it to the user's characteristics is pedagogically beneficial.

In this paper we have described a three-tier adaptation mechanism to personalize educational computer games according to several special characteristics of small children. These games compose the user interface of SHAIEx, a web-based adaptive hypermedia system designed for learning English in pre-school education. This mechanism is based in a XML configuration file. The schema of this file is easily extensible to other adaptation parameters.

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