MITO: an Educational Game for Learning Spanish Orthography

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Abstract. An educational game is a recreational activity designed to teach people, typically children, about a certain subject or help them learn a skill as they play. These games are usually successful in engagement, but sometimes fail in triggering learning. When designing an educational game for children, a way to avoid this could be to take into account the cognitive stage of the final user, as defined in Piaget's cognitive development theory. This paper briefly explains the fundamentals of this theory and discusses its implications in the design and development of an educational game to learn Spanish orthography, focused on children on the concrete operational stage.

1 Introduction

Learner motivation is one of the main objectives of any pedagogical activity. Electronic educational games are learning and recreational environments that try to increase the learner's motivation by embedding pedagogical activities in highly enjoyable interactions. In [1], a former review of literature on the effectiveness of games versus traditional classroom instruction is made. By analysing 68 studies from 1963-1991 in social science, math, language arts, logic, physic and biology, it was determined that games were more effective in the domains of language arts and mathematics. The reason is that, in these fields, greater specificity of content and more effective use of computers created a clear advantage for the exercises over traditional teaching methods. Furthermore, greater retention was shown in games, and students reported greater interest in game activities than in more conventional classroom instruction. However, there is little empirical evidence that electronic educational games can promote learning unless the interaction is led by teachers and integrated with other instructional activities [2]. A possible reason for this limitation is that learning how to play does not imply learning the domain [3].

Another important point that must be taken into account for learner motivation is that the educational game should adapt the proposed activities to the learner's cognitive stage. Probably, one of the most accurate and commonly used definitions of children cognitive stages is the defined by Piaget's theory of cognitive development [4], [5]. The cognitive abilities that Piaget studied are important when teaching young students, as they help determine how much and in what way students will understand the topic being taught.

Next section explains briefly the theory of cognitive development and the kind of games appropriate for children in the concrete operational stage (target of our system), and some considerations about designing and developing good educational games. Section 3 presents a short review of related work. Then, the electronic educational game MITO (which stands for

Multimedia Intelligent Tutor of Orthography) is presented. MITO[1] is a stand-alone application focused to help children between 8 and 12 years old learn Spanish orthography. Finally, the paper concludes by presenting some conclusions and future lines of research.

2 Psychological considerations for the design and development of educational games

This section is structured as follows: first a short description of Piagetian cognitive stages is presented. Then, the more appropriate games for each stage are discussed, and finally some considerations about the relevant features of a "good" educational game are made.
Piaget theorised that intelligence is built on in a series of stages. These stages always appear in the same order and can usually be determined by a child's age. Piaget also found there was sometimes deviations from the norm as well as possible acceleration or delay in mental age and abilities. This lead him to believe there was more than biological maturation creating the different developmental stages [5]. These four stages are: sensorimotor stage (0-2 years); preoperational stage (2-7 years); concrete operational stage (7-11 years), and formal operational stage (11-15 years). As our game has been developed for the concrete operational stage, we will only present relevant information concerning that stage:

In the concrete operational stage, children are capable of taking another person's point of view and incorporating more than one perspective simultaneously. At this stage the child begins to think logically with concrete knowledge. They understand conservation and their way of thinking is reversible (they can follow their line of reasoning back to its starting point). Their thought pattern is now logical and systematic, making it easier for them to find answers to simple problems (classification, combinations, etc.). Main limitations are the lack of abstraction capabilities and that usually thinking is limited to two characteristics at the same time. Piaget found that, though all children went through the stages of learning in the same order; the age that an individual progressed to the next stage could be quickened or stunted depending on how stimulating the learning environment is. This consideration should be taken into account when designing educational games for children.

In [6] we can find the relevant characteristics and more appropriate games for each stage. Such information for the concrete operational stage is summarized in columns 2 and 3 of Table 1, while in column 4 we show our conclusions about the implications in the design of good educational games for each period.

STAGE	RELEVANT CHARACTERISTICS	APPROPRIATE GAMES	IMPLICATIONS FOR COMPUTER EDUC. GAMES
CONCRETE OPERATIONAL STAGE	Children in this stage to represent things mentally and to manipulate such representations. They are able to tackle with different points of view, however they still lack abstraction capabilities.	Games with rules, figurines, characters, learning and informative toys, constructions, arts and crafts, remote control items, video and computer games	Almost any game (apart from those that need abstraction) can be included in an educational game and help in triggering significant learning.

Table 1. Relevant information for the design of games for the concrete operational stage

With regard to the definition of the "quality" of an educational game, we have made a literature review looking for relevant features that good games share. Next we present a list with useful quotations found in this literature review (together with some comments). From this quotations, a list of keywords that describe desirable features of a good educational game

[1] MITO is a tool designed with educational and non-commercial purposes. Installation files and instructions are accesible at http://www.lcc.uma.es/~eva/mito.

has been extracted. Such keywords are presented in brackets in the text, and will serve as a basis for the design of our educational game.

- "Like all instructional materials, educational games need to be developmentally appropriate. A specific game should be appealing and accessible to the target level of development" [7]. (CHALLENGING, ACCESSIBILITY, ADAPTATION).
- "Students must overcome many barriers to engagement, including fear of failure, fear of embarrassment, and aversion to losing control" [8]. (PRIVACY).
- "Game engages players through interactivity. Players take ownership of their choices, because those choices influence the outcome…. Success in a game can usually be clearly traced to effort and ability" [8]. (INTERACTIVITY, OUTCOMES, REINFORCEMENT, IMMEDIACY).
- "Good games are often distinguished by great freedom" [8]. To this respect, we would like to remark that such freedom must be supported with techniques to avoid confusion and disorientation. (NAVIGATIONAL FREEDOM, ORIENTATION).
- "A model of reinforcement and conditioning predicts that players will repeat behaviours that are rewarded and abandon behaviours that are ignored or punished" [8]. (REINFORCEMENT).
- "A good game…is one that children want to play again and again. There are several characteristics that good games share: the goal and rules are clear (SIMPLICITY, ORIENTATION); it's easy for players to keep track of their progress as they play (OUTCOMES); the game can be played with a variety of strategies; the game offers variety (for instance, because players can make different choices, or the game contains a random element such as a die) (VARIETY); and the game is so motivating that children are willing to persevere when facing challenges and to work to improve their strategies so they can become better players (MOTIVATION). Although many educational computer games available today offer attention-getting graphics, sound, and other special effects, these can become tiresome if the game itself is not well-structured and appropriately challenging" [9] (WELL-STRUCTURED, CHALLENGING). This paragraph provided with a good set of keywords (inserted in the quotation), but in our opinion a good educational game must not only fulfil the requirement "children want to play again and again", but also trigger significant learning (LEARNING EFFECTIVENESS).
- Finally we would like to add a feature to this list: in the case that a child reaches an impasse, a good game should provide immediate assistance (by means of hints/feedback) to avoid frustration (SUPPORT).

To sum up, the list (in alphabetical order) of relevant features (keywords) of a good educational game is: ACCESSIBILITY, ADAPTATION, CHALLENGING, IMMEDIACY, INTERACTIVITY, LEARNING EFFECTIVENESS, MOTIVATION, NAVIGATIONAL FREEDOM, ORIENTATION, PRIVACY, OUTCOMES, REINFORCEMENT, SIMPLICITY, SUPPORT, VARIETY, WELL-STRUCTURED.

3 Related work

Examples of educational systems designed for children and based on Piagetian stages of cognitive development are not easily found in research. An interesting work in this field is presented in [12], where Piaget's notion of cognitive development has been used in the building of pre-test that would allow improving a tutor's reasoning ability. MFD (mixed numbers, fractions and decimals) [13] is an Intelligent Tutoring System (ITS) aimed at teaching fractions, decimals and whole numbers to elementary school students. Students with different levels of cognitive development should behave differently in the tutor, and that is the

reason why they need to be taught with different strategies. Before the students begin to use the tutor, they are given a computer-based pre-test that measure their level of cognitive development. The pre-test is composed by ten Piagetian tasks that determine if the students are at one of the last two stages of cognitive development (concrete operational stage and formal operational stage). The test includes exercises about number conservation, serialization, reciprocity; area conservation, class inclusion, functionality, reversibility, establishment of hypotheses, control of variables in experimental design, drawing of conclusions, proportionality; and combinatorial analysis. This measure predicts student performance at a variety of grain sizes: effectiveness of hints received, rate of failure, amount of time to solve problems, and number of problems students need to attempt to master a topic. Later on, same authors presented an independent, adaptive, and easy-to-integrate web-based component to evaluate a student's cognitive development that can be used as the pre-test of any ITS [14]. This component was constructed by including existing test's items [12] into the SIETTE [15] web-based adaptive testing system.

4 An example: the design and development of MITO

With these ideas in mind, in our group we have developed an educational game for Spanish orthography that has been developed for children in the concrete operational stage. For a definition of orthography, we have consulted some dictionaries:

- American Heritage: The art or study of correct spelling according to established usage
- *Real Academia de la Lengua*: Set of rules that determine the writing of a language

We can see that, in the case of Spanish, the word "orthography" has a different meaning. The most significant differences between English and Spanish writing systems are that in the case of spanish a) the correspondence between graphemes and phonemes is regular, with very few exceptions; and b) there is a (quite) reduced set of rules that completely determine how each word is spelled. So, though usually the best way to learn orthography is to read a lot (books, etc.) and then to use the visual memory to recall how a word must be spelled, in the case of Spanish rules are always a reliable way to know the correct spell for a word. So for example, in Spanish orthography there is a rule that states:

"before p or b m and not n should be written"

A simple rule like this determines that the correct spelling is "también" and not "tanbién", "tampoco" and not "tanpoco", and so on. In this way, learning orthography is simpler than in the case of English, as new speakers do not need rote learning of words.

In any case, either if rote learning is needed or if there is a set of rules (with their corresponding exceptions) that completely determines word spelling, orthography is an arid domain to be taught. Yet, the importance of learning orthography is clear because the ability to write correctly is fundamental in any professional environment.

However, our view of how orthography should be taught is not based in learning the rules, but shares the directions presented in [10], which we briefly explain next: to our purposes, orthography will be used as a synonymous of "correctly spelling the words". Therefore our main goal will be to teach the strategy that persons with good orthography apply. Solving exercises is not effective if the mental strategy is wrong, so the fundamental thing is to teach a mental process, which can be described as follows:

a) When in doubt, good writers mentally search for the image of the word and visualize it in their minds. Writing becomes then a copy of the word that has previously been stored in their minds.
b) This visual recall of the word can be good enough to be confident on its correctness, but in some cases doubts can be clarified by writing the word in the different ways.

Consequently, a goal when developing MITO is to help in using visual memory for orthography (by showing correctly and incorrectly written words).

As also stated in [10], in order to learn Spanish orthography, the student must satisfy some conditions:

a) Be advanced in the concrete operational stage (about eight years),
b) Being able to write and read at a reasonable speed,
c) Being aware of the existence of rules and exceptions,
d) Being motivated to improve (though our system is designed to improve motivation).

Though MITO is a game designed for children in the concrete operational stage, it can also be used by adults. At this stage, children can understand rules and apply them to games, so the learning and use of orthography rules is an appropriate task for them.

The contents in MITO are divided in four modules that aim to teach words corresponding to different sets of rules: a) Written accent rules; b) H, G and J rules; c) B, V, C, Z, D and Q rules; and d) M, N, Y, LL, R and RR rules. As explained before, rules are used to provide support to being able to correctly spell the words but are not considered as learning goals (because for us it is more important to know the correct spelling of a word than the rule that applies). In this sense, rules are used in our system to group the exercises to be posed to the student. A Disney©[2] character is associated to each module.

For each learner, MITO creates and maintains a simple student model that keeps record of the number of correctly solved exercises of each module (represented by its associated character). To increase motivation and facilitate navigation, this simple student model is inspectable by pressing the button "*Ver resultados*" (show results). Figure 1 shows the initial screen and an example of such student model.

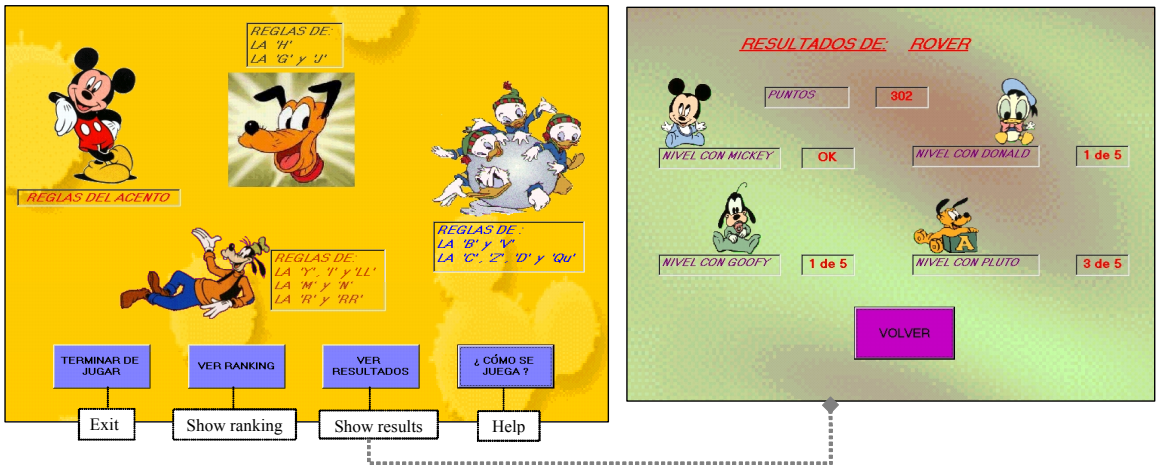

Fig 1. Screenshots of the main menu and the inspectable student model

In order to achieve the learning goals fixed, MITO presents the following features (he associated keywords are shown in brackets):

- The user can choose a different module at any moment (NAVIGATIONAL FREEDOM, INTERACTIVITY).
- Each exercise is explained briefly, but a more complete explanation can be shown by user's demand (SIMPLICITY, ACCESSIBILITY).
- The user's answers are checked immediately (IMMEDIACY).

[2] Disney characters were taken from http://clipart.disneysites.com and are used in our application with no commercial purposes.

- Each group is divided in several different exercises (VARIETY) that progressively get more complicated (i.e, apply more or more difficult rules) as the user correctly solves them (CHALLENGING). In order to trigger learning, the user must show knowledge about between 90% and 100% of a module's content (either by visual memory or by direct application of its rules) to be able to finish it (LEARNING EFFECTIVENESS).
- The system has a help mechanism (triggered by the user just pressing a "help" button) that explains the rules in an accurate and clear way. This help is context depending and can be shown by user's demand (SIMPLICITY, SUPPORT).
- Feedback messages are provided immediately (for both the cases of correct and incorrect answer) and are clear and brief (orthography rules are used as a basis for explanations) (SUPPORT, IMMEDIACY).
- There are many multimedia elements (childish sounds, nice pictures, etc.) designed to keep the user motivated. Also, the goal of the game is the goal is to help one Disney character reach another (see for example fig. 2 where each time the student provides the right answer, Pluto moves forward one position to reach Mickey) (MOTIVATION)
- As the user goes on with the game, his/her knowledge about the topic increases and the system adaptively selects more difficult exercises. (ADAPTATION, CHALLENGING, WELL-STRUCTURED)
- The system keeps a simple student model that is updated in every exercise. (OUTCOMES)
- At any moment, the user can see his/her student model. (OUTCOMES, ORIENTATION)
- Each time the user correctly solves an exercise, some points are granted (REINFORCEMENT).
- MITO keeps record of the score reached by its registered users, which is available at any time. The ranking of results of all registered players can be seen at any moment by pressing the button "*Ver ranking*". In this way, competition triggers motivation and keep the children engaged. (MOTIVATION)

Figure 2 shows an exercise in MITO:

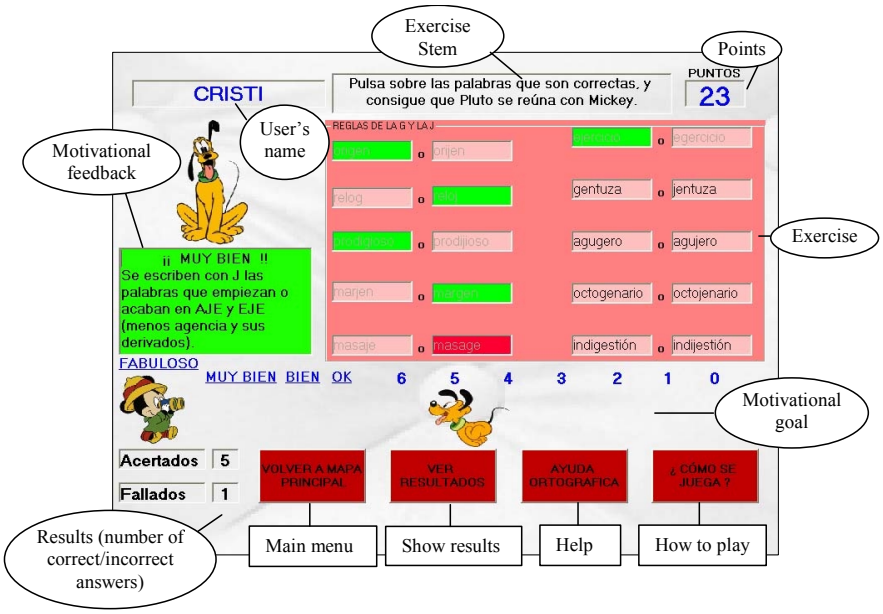

Fig. 2. An exercise in MITO

The relevant elements are (from left to right and from up to down): user name, exercise stem, points reached, motivational feedback, window of the exercise (which in this case consists of selecting the correct word between the two possibilities), motivational goal (in this case, Pluto must reach Mickey and each correct answer will move him one position forward), number of correct and incorrect answers in this exercise and four buttons: main menu, show

results, help, how to play (that provides an extended game description).When the student selects a word in the exercise, the background is changed to green if it is correct and to red if incorrect, and a childish voice congratulates or scolds the action while showing appropriate feedback (in this case, the corresponding rule).

MITO has a simple but effective architecture, which is shown in Figure 3. The interaction begins in the *Input Module*, where the system gets the user information. Then, the system gives access to the *Main Menu*, where he/she selects a module/game to play. The user can always access *Output Module* and leave the game (his/her student model will be saved for future sessions). The *Learner Diagnosis Module* controls the user model and provides this information when requested. The modules do not communicate with the expert module directly, but using the *Help Module* and the *Error Module*. The expert module contains the knowledge domain and structures the contents in a hierarchical way.

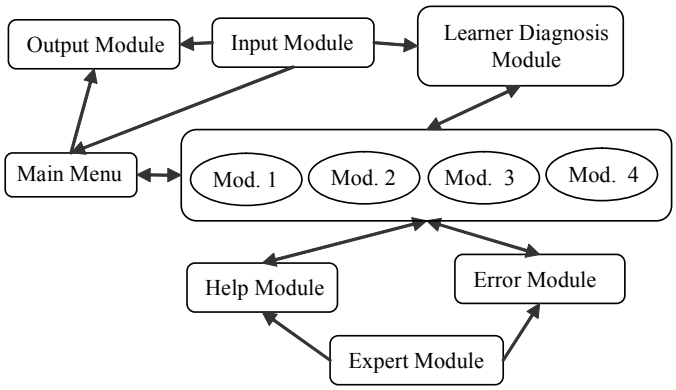

Fig. 3. MITO's architecture

5 Preliminary evaluation results

A formative evaluation of the MITO system has been performed. This evaluation had two main goals: a) to determine the degree of acceptance of the game among the users it was focused to, identifying relevant aspects that can improve learner's motivation and b) to study the effectiveness of the game in helping children to learn orthography, identifying possible ways to improve the design and behaviour of the system from an educational point of view. At this stage of our work, the evaluation was formative, so no numerical recollection and analysis of data has been performed. Instead, seven children (from 6 to nine years old and native Spanish speakers) were asked to play and a human tutor observed their behaviour and assisted them when needed (children had different computer literacy degrees, so some of them needed more support than others, though in general we found that the system was very easy to use and children only needed assistance at the very beginning).

Regarding the motivational aspects, first results have been very encouraging. Children did really become very engaged with the game and did not want to leave it until they completed all the modules. The features of the system that they liked better were the multimedia aspects, i.e., Disney characters and childish sounds (which fully fulfilled their goal to capture children's attention). The fact that they could help their favourite character to reach a goal was also very motivating, as also was the possibility to see their position in the ranking.

However, results in the use of feedback/help messages to trigger learning were not so good. More than half of the children did not want to pay any attention to feedback messages, even when pointed out that these messages could give a clue for the next exercise. Help was neither used by children, who only wanted to quickly get the correct answer from their tutor and keep playing. When reaching an impasse, most children asked their tutor for the correct answer, but very few of them tried to use help. In our opinion the

reason is that, even when help messages are short and clear, children were too involved with the game and did not want to waste their time in reading. However, during the experiment we observed that children were willing to accept help from the human tutor instead of the correct answer, if it was presented as a "trick" that could provide the answer to not only the current exercise but probably to the subsequent ones. This gave us the idea that, probably, the use of a personal helping agent (as in [11]) could improve the effectiveness of the system from an educational point of view. The helping agent could be a fairy, an angel, etc. that would be assigned to the children at the beginning of the interaction and presented as a friend that can be called to provide help by means of "tricks" (simplified orthographic rules) when needed.

Though the system has been designed for children, we have also tested it with some adults (mostly illiteracy adults that were learning how to read and write). In this case, even when the images and sounds were very childish, people usually found them funny. The main difference is that help and feedback messages had the desired effect both capturing attention and triggering comprehension and learning. Ironically, the competitive aspect was the main motivating element in adult users.

6 Conclusions and future work

Our main goal while developing MITO was to build an application for children that could help them in the somewhat tedious but very important task of learning Spanish orthography. To this end, motivational aspects have had a great importance in the design and development of the system, and a first formative evaluation shows encouraging results regarding motivation. This evaluation also showed some weaknesses of the system, like the limited use of feedback and help messages. The reason possibly is that children get so involved in the game that they only want to go on playing to reach the maximum score, and therefore they do not want to lose their time in reading these messages. A possible solution that will be investigated and implemented is the introduction of a personal agent, which can provide help in a friendly way, presenting it like "tricks" that not only will help in the current exercise but will also serve to pass others. In the evaluation, the tutor played this role with satisfactory results, so probably the inclusion of such agents in the system will help in triggering significant learning.

Other improvements of the system we are planning include the development of an interface for tutors/parents that allows the inclusion of new words, to provide a greater variety of the exercises posed to the student. Finally, a formative evaluation of the whole system (the design of such evaluation has not been carried out yet) will be conducted in real settings to evaluate the effectiveness of the game in terms of the gain of significant learning.

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