DESIGN OF DIGITAL EDUCATIONAL MATERIALS FOR PRIMARY EDUCATION

Isabel Cuadrado Gordillo and Inmaculada Fernández Antelo
Department of Psychology and Anthropology, University of Extremadura, Badajoz, Spain

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Abstract: The design of multimedia materials adopted in our proposal is based on a constructivist centred approach in providing the children with mediated learning experiences that foster the acquisition of strategies and the self-regulation of their learning process. To this end, we use the figure of a mascot who acts as their guide in resolving tasks set them in language, mathematics, and environmental knowledge. The guidance is not limited to telling them that their answer is right or wrong, but attempts to get them to reflect on the procedures they applied, the mistakes they might have made, the relationships that have to be established between the different concepts involved in the problem, the cognitive strategies they have to put into effect to complete the task, etc. This design is wrapped in a series of adventure games matching the centres of interest shown by children according to their age.

1 INTRODUCTION

This presentation forms part of a Research Project centred on the design and production of multimedia educational materials targeted at the content of Language, Environmental Knowledge, and Mathematics in Primary Education. The materials provide a new way to work on these curricular areas from a threefold perspective – interactivity, flexibility, and adaptation to the individual needs of each child. Its design therefore moves away from the behaviourist approaches and the types of programmed education that still characterize most educational software for working on school-level content. It also moves away from the design followed in the simulation and microworld programs proposed by Papert (1981) in not requiring the pupils to have any prior knowledge of programming in order to interact with the program, and in fostering the social aspect of learning through collaborative activities. For this last objective, the activities are situated on virtual platforms that enable simultaneous access for sharing and discussing the content and how to execute the program. Our proposal is centred on providing the children with mediated learning experiences that foster the acquisition of strategies and the self-regulation of their learning process.

The design is implemented in a scenario that is attractive and close to the pupils – a Natural Park, in this case, Monfragüe. Wrapping the activities in a series of adventure games matched to the interest centres shown by children according to their age allows the pupils on the one hand to get to know the flora and fauna inhabiting this environment, and on the other motivates and involves them in their learning.

2 METHOD

The method followed in preparing and presenting the tasks for the pupils to do is based on three core aspects:

- The **design of a game** for each block of content in which to insert the activities for the pupils to do. These games set the children different challenges, for example, to rescue a princess from the castle, to prevent fires in a natural park, to repopulate with trout a river where animals threatened with extinction feed, etc. In this way, besides working on certain attitudes related to coexisting with and respecting nature, we arouse the pupil's curiosity and interest in the tasks to be done. To meet these challenges, the pupils are proposed a variable number of

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tests that will require them to resolve activities corresponding to material in mathematics, language, or environmental knowledge (Amory, 2001; Amory, Naicker, Vincent & Adams, 1999).

- **Story Construction**. The objective is for the child to imagine existing and potential relationships between different parts of reality. It involves the need to connect facts and situations with objects and their contexts, and this requires constructing meanings. Stories give us a better understanding than simple abstract presentations (Brown, 2007).

  The stories that we present are diverse, and we believe that this is the natural way to construct, explore, and solve learning tasks. But they always require a context. The objects and facts that will make up the stories need to be put into context, in this case, therefore, by reference to the Monfragüe Natural Park. Consequently, describing the context of a Natural Park involves re-assessing its role in learning (an essential activity of environmental education).
- **The Use of Mascots** (a stork, a boy, a forest warden, a princess), at different levels of difficulty, as a means of interaction with the pupil. They also constitute a highly motivating element, and provide pupils with clues to reflection when their cognitive processes fail.

Matching these tasks to the pupils' educational needs led us to include a series of measures targeted at specific deficiencies or impairments. To deal with the case of pupils with a hearing disability, all the activities and hints to help with their resolution appear in text on the screen. For the case of visually impaired pupils, besides the activities and hints being presented as speech, we designed a tool that allows them to increase the size of the elements that appear on the screen. Finally, for the case of pupils with a mental deficiency or a marked lag in maturing, the same activities can be presented at one of three different difficulty levels. In this way, a priori there is the sensation that all the pupils are working on the same activity, because the statement of their activity and the photographs, videos, and characters making up the story on their screens are the same. However, the resolution of the activity will in some cases involve more complex cognitive strategies and greater previous knowledge than in other cases. Thus, for example, in the area of mathematics, and specifically in the content block of addition and subtraction, in Level I the addition problem requires operations that do not exceed the tens and requires no application of the concept of carrying. In Level II, this same problem will be of a combinatorial type using up to the thousands and involving carrying. In Level III, as well as the application of carrying and increasing the units to the tens or hundreds of thousands, the problem statement may be put in the form of a comparison, which requires a greater capacity of understanding and decoding than the previous cases.

3 GENERAL CONSIDERATIONS CONCERNING THE DESIGN OF THE ACTIVITIES

- The activities included in each thematic block deal firstly with knowledge of a natural environment and some of the elements to be found in it, and secondly with a situation invented to generate in the child the need to solve the problem or activity. In as much as the activity arouses the pupils' curiosity and shows itself to be relevant and useful in fields that are of interest to them, it will increase their willingness to take a real part in carrying it out.
- All the activities are based on problem-solving. The idea is not for the child to learn a set of formulas or concepts and be able to reproduce them faithfully, but rather to be able to apply that knowledge to real specific cases, that are, in so far as is possible, close to his or her sociocultural context (Cuadrado & Fernández, 2006). For example, it does not interest us whether or not the child knows the classification of the animals or plants by memory, but that, after the presentation of some of these elements which are presumably going to be familiar, he or she knows how to classify them by observing and analyzing their characteristics.
- The level of complexity of the activities included in each level of each block is increased progressively. I.e., we work on some concept in the first activities. After the resolution of these, we assume that this concept has been assimilated and propose activities that work on a new concept related to the former one. In this way, besides progress in the learning process, we try to establish conceptual relationships between elements of the content being presented and to show their continuity. For example, we first approach addition without carrying, and then later progress to addition with carrying. Or we first work on multiplication by a single figure, to later increase the number of figures and

progressively introduce the properties of multiplication.

- At each level, the pupils work with concepts from the previous level by way of review. In this way, we facilitate the establishment of cognitive bridges between what they already know and the new content.
- The dynamics of solving the different problems is open to different strategies that the child might use. I.e., one does not oblige the child to follow a certain path to do the activity, but makes almost all the possible ways of solving a problem available for the child to choose the one that is best adapted to his or her thinking. This involves including all the variants consistent with resolving some given exercise, from the more pictorial to the more algebraic or abstract, or from those in which the pupil chooses to first construct a conceptual map and then to use its content to solve the task, to those in which the pupil decides to answer the questions directly. But in addition, the design of these materials allows the child to choose even a path that does not lead to a satisfactory or correct resolution of the task. Sometimes one needs to make mistakes to detect which conceptual relationships remain to be established, what previous knowledge was wrong or incomplete, etc. Experimentation fosters the awareness of the steps or procedures to follow that are best suited to each type of activity, and this is only achieved by designing materials that allow a path to be followed that does not necessarily lead to the correct answer (Cuadrado & Fernández, 2003).
- Solving the problems or tasks is doubly motivating. On the one hand, each problem forms part of the general dynamics of a game (a different game for each block of content) in which the child must solve the problem to continue playing (Amory, 2001). And on the other, the game represents an accessible challenge for the pupils, creating in them the desire to continue to the end to see the result of their small achievements, such as, for example, seeing the utility of having created a fire-break when a fire occurs, saving a princess thanks to obtaining the ingredients needed to make the magic potion, etc. Also, the dynamics of the presentation of each game offers the opportunity to see, from photos or videos, the components of the problem. For example, in an activity in which the question is how many rabbits are needed to feed the colony of Eurasian black vultures in Monfragüe, the pupils can access the photo, the video, or the technical information page of both the rabbit and the vulture.
- In the mascots' presentation of the activities, the text on the screen includes words in red. These are words that we understand may be difficult to understand at that level. Therefore, clicking on them or simply hovering the cursor over them brings up a text box clarifying their meaning.

4 MAIN EDUCATIONAL CONTRIBUTIONS OF THE NEW DIGITAL MATERIALS

Apart from the form and external structure characterizing the design of these activities, the main educational contribution of these materials is in their commitment to meaningful learning in the context of Vygotsky's zone of proximal development. In this sense, each activity is accompanied by a series of hints that are activated when the pupil makes a mistake. Their purpose is to elicit the pupil's metacognitive awareness by indicating which is the mistake detected, why it is considered to be a mistake, and inciting reflection on which strategies or procedures should be used to correct this error and finish the task (Teong, 2002). This involves foreseeing the possible mistakes that the pupils may make during the activity, and providing for each of them the relationship of the given information with the pupils' prior knowledge. In the case of a successful response also, this type of relationship is established in order to eliminate the effects of chance and to explain to the pupil why the given answer is correct and what part of his or her prior knowledge is related to it.

Therefore, whether the pupil's response is right or wrong, the mascot is not limited to saying just this, or, when called for, to replacing these visual messages with a variety of sounds and animations aimed at capturing the child's attention.

Instead, firstly it will guide the learning process by attempting to get the pupil to fix on the data that are provided in the problem. To this end, it will ensure that the pupil has read the problem comprehensively, and understands what is asked, by means of a series of questions that vary according to the data involved.

Secondly, it will check the child's degree of understanding of a certain concept or item of curricular content. If the pupil has answered correctly, the mascot relates the given answer to other content to explain why this answer is

considered valid. If the answer was wrong, the mascot will go back to earlier concepts to check the child's previous knowledge and then relate that knowledge to the content and activities now being presented. Nonetheless, this does not imply relegating the teacher to a background role or replacing him or her by a mascot or program computer. Neither does it imply encouraging the pupil's solitary learning (Crook, 1998). The design of these activities strengthens the teacher's role of guide fostering the pupil's self-regulation of their learning. The teacher constantly selects, organizes, orients, adjusts, and graduates the aid that the children need to overcome the difficulties and obstacles that they come across. The computer material is just one more educational medium that the teacher has available.

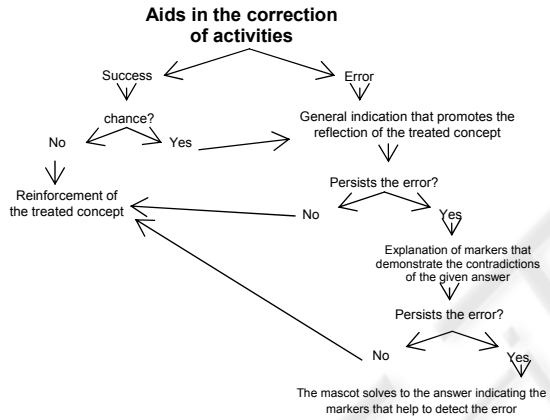

Figure 1: Process of the interaction in the correction of activities.

And thirdly, the pupil is presented with activities of progressive difficulty specifically aimed at dealing with the conceptual and procedural errors that he or she has made previously. With respect to the concepts, the material covers all the content in the primary education curriculum, working simultaneously on aspects of language, mathematics, and environmental knowledge. For example, the solution of a geometry problem includes topics related to the knowledge of certain characteristics of plants, the popular traditions of a zone, the birth indices of an animal species, reading comprehension, spelling, and written expression, as well as the purely mathematical topics related to geometry such as quadrilaterals.

With respect to procedures, the activities are designed to offer the pupil different paths to the solution. I.e., the task can be completed by applying a procedure that the pupil knows well, or considers most suitable or easiest, etc. The guidance given by the mascot in this sense is directed on the one hand towards the use of those procedures that best match the knowledge that the child has been found to have, and on the other towards the characteristics of the task. In sum, the mascot's guidance is aimed at the acquisition of strategic behaviour.

With respect to the block dealing with attitudes, these are present in all the statements of the activities, in the design of the games, and in a large part of the indications given by the mascot, independently of the area of knowledge that is being worked on.

5 PROJECTION AND USE OF THESE MATERIALS ON THE WEB AND IN THE CLASSROOM

The reasons making it possible for these digital multimedia materials to be available for the next school year in all the classrooms of Extremadura are many and various:

- The fact of covering most of the primary education curricular content in the areas of Language, Mathematics, and Environmental Knowledge.
- The treatment given to the material, as well as the psychopædagogical approach underlying it.
- Its flexibility and capacity for adjustment to the real-time educational needs presented by the pupils and the school in general (Gértrudix, Gálvez de la Cuesta, Álvarez & Galisteo del Valle, 2007).
- Two basic aspects of the current reality of the technological infrastructure of Extremadura: the existence in all Extremadura's schools of a computer for every two pupils, and the possibility of using an intranet and a set of virtual platforms capable of allowing the entire educational community network access to the material.
- The support and interest of the Board of Education of the Extremadura Local Government as materialized in the concession of a major budgetary allowance for computerization of the Region's education system.

But the utility and dissemination of this material go beyond their presence in Extremadura's classrooms. Open and free access to it on the Web make it

possible for teachers all over the world to work with their pupils in a constructive, interactive, dynamic, and attractive way on the curricular content that it covers.

The challenge now is to train the teachers in the use of digital materials stored and distributed on digital networks. Nevertheless, according to statements made by teachers themselves, this training should not be centred on the acquisition of technical knowledge, but on the knowledge of the educational implications and psychopedagogical foundations deriving from the design and use of the different digital materials that are available. Teachers need to identify the skills, abilities, and strategies fostered by the multimedia materials that they work with in their classrooms, the difficulties that their pupils will come across, and the other educational instruments they will need to use to overcome the deficiencies or to enhance the strengths of the digital materials that they work with.

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