# Towards the Efficient Communication of Knowledge in an Adaptive Multimedia Interface

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**Abstract.** This paper presents the instruction design for interaction and knowledge communication in an Adaptive Multimedia Interface. This interface takes parts in an Intelligent Tutorial System (ITS) for intellectual and cognitive handicapped children. There are available many educational programs for helping students but in general they do not consider the adaptation of the performed tasks and teaching strategies to the individual characteristics of each one of the children. The aim of this work is designing the multimedia interface for supporting different teaching strategies that can be adapted according to the particularities of the pupil.

One of the most important problems that has arose is the extraction of the pedagogic knowledge. This type of knowledge takes a fundamental role in deciding the strategies that this interface is going to follow. Therefore, this paper outlines previous researches in our understanding of student learning in terms of styles and strategies.

The fundamental problems that are approached in this paper are: the acquisition of the pedagogic knowledge, the design of the interface that is embedded in an ITS, and instruction design for implementing an efficient interaction and communication of knowledge.

**Keywords**

Multimedia and multimodal interfaces **-**Configurable, adaptable and adaptive interfaces **-**Communication**-**Education and skill development **-**Human Factors and usability issues

## 1- INTRODUCTION

This paper describes the instruction design for effective knowledge communication and the implementation of a multimedia interface that takes part in an ITS. The goal of this interface is to adapt the presentation of the contents to the individual needs of the students with intellectual and cognitive handicaps.

Currently, there are available many software applications where different educational levels are considered. However, generally speaking they do not satisfy the high-specialised requirements of this kind of pupils. The educational contents that these children have to learn are defined in the Spanish curriculum. The difference between these students and others is that they learn more slowly so that they require a more individualised teaching.

The most commonly used instruction environments use one-to-many or one-to-one instructor learner relationship and they do not take into account the individual features of the final receptors of contents. They do not change the teaching strategies according to the requirements of each user. Another drawback is that the proposed tasks are presented following a repetitive sequence. This fact limits its application to students with learning problems: the motivation of the student along the automatic tutoring is affected negatively and the uncertainty about what the student is learning: the concept or the repetitive pattern showed by the software.

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Our goals are, firstly the implementation of a multimedia interface where the presentation of the educational contents is adapted to the individual characteristics and preferences of the student.

The second goal is the incorporation of different teaching and learning strategies. For this reason, we have developed a tool that helps the teachers in the design their own instructional program.

We have based our system in the frame of the General Law for the Spanish Educational System. This study has been restricted to the Childhood Educational Period.

Our system tries to represent several styles of instruction. It is important to remark that the teaching strategies are used to build the logic flow of the activities presented to children, and pedagogues provide them.

The benefits of using a tool as this one come from the individualised teaching of the students. Regarding this aspect we considered learning styles because we all have learning preferences, which enable us to learn more effectively.

The three most important problems approached in this paper are:

- The acquisition of pedagogical knowledge.
- The design of an adaptive multimedia interface.
- The instruction design for an efficient interaction and knowledge communication.

This paper has been organised as follows. Firstly, we described the acquisition of pedagogical knowledge, Then we explained the design of a multimedia interface embedded in an ITS. Afterwards, we presented an instruction design to build an efficient way to transmit knowledge.

## 2- PEDAGOGICAL KNOWLEDGE ACQUISITION

Knowledge acquisition is the process of elicitation, analyzation, interpretation and transformation of an human expert's knowledge to a machine representation or a program.

However, the quality of an expert system depends on the quality of the knowledge acquisition and, thus knowledge acquisition is a crucial and critical stage in the development of an expert system.

Knowledge acquisition must be performed with a structured methodology in order to decrease design, implementation, testing and maintenance costs. In this work we have followed a structured methodology known as KADS that permits the knowledge engineer to solve the previously remarked complex problems. Using this methodology makes possible reusing the expert knowledge [1].

This methodology allows us to build the Knowledge Based System (KBS) in a comprehensive and systematic way: the Pedagogic, the Didactic and the Student Model are represented in the KBS.

The KBS has to be fed with a student model that is composed of two parts: profile and records. The slow-varying characteristics of the student related with his personality and physical conditions (preferences, visual performance, ...) are included in the profile. The records take into consideration the variables that measure how well the concepts have been learned, and the trajectory followed by the student to reach these levels (tasks that have been repeated, tasks that have not been completed, ...). In our Student Model, the Profile involves the following characteristics: name, attention, learning level, preferences (colour, fondness, etc.), personality features, visual level, chronological age, cognitive age. Therefore, the Records save the student progress regarding to domain concepts. These concepts are determined for a cognitive age and it belongs to an area. This area is included in a block of knowledge. Finally, related with the concept there are a set of learning goals.

In addition, it is necessary to provide the KBS with the pedagogic strategies followed by the teachers in the teaching process. For this reason, another fundamental part of the domain knowledge in the KBS, is the pedagogic model, where both the learning goals and the way they are taught are included. That is, for each student, the activities that are proposed to teach a particular concept are specified taking into account the records of student. [2]

One of the most important problems that have arisen is the extraction of the pedagogical knowledge. This type of knowledge takes a fundamental role in deciding the strategies that this interface is going to follow.

More precisely, the pedagogic, didactic and student models can only be extracted using this knowledge.

The following section introduces a particular application that supports the process of knowledge acquisition.

### 2.1 Acquisition Knowledge Tool

We have developed a software application that helps in the acquisition of the expert knowledge. We have considered two simultaneous goals. a) To make easier for teachers, the construction of their own learning activities. b) To register what activities the teacher carries out in order to explain a particular concept to a specific student, what goals considers, what kind of media utilises, and finally, what positive and negative reinforcements applies after the result of the activity has been obtained.

We have provided the teachers with a tool that helps them in checking the benefits of different strategies to approach the teaching task of a particular concept.

The focus was on the design of wizards to helps teachers in the construction of educational programs that allow for the incorporation of teaching and learning strategies. Incorporation of teaching and learning strategies within the wizard can be achieved by embedding visual and audio prompts, time-out detectors, and a variety of user options, such as feedback specifications. The techniques used were implemented with Macromedia Authorware version 5.0 and the technology of Knowledge Object (Figure 1).

With this model, educators work independently at their own time and pace. They are provided with the means to design, produce and modify their own instructional programs thus relevant teaching and learning strategies may easily be incorporated within a common design. This gives educators greater control over course presentation and learner performance. Using this program, the educator can effectively become the creator of an individualised learning tool. But, with this wizard we have registered the logic flow used for the teachers to teach a particular concept. Our goal is to design a multimedia interface that support these teaching strategies to adapt the way of presentation of the contents to student's individuals needs.

In the following section, we will introduce an implementation of our design of the adaptive multimedia interface.

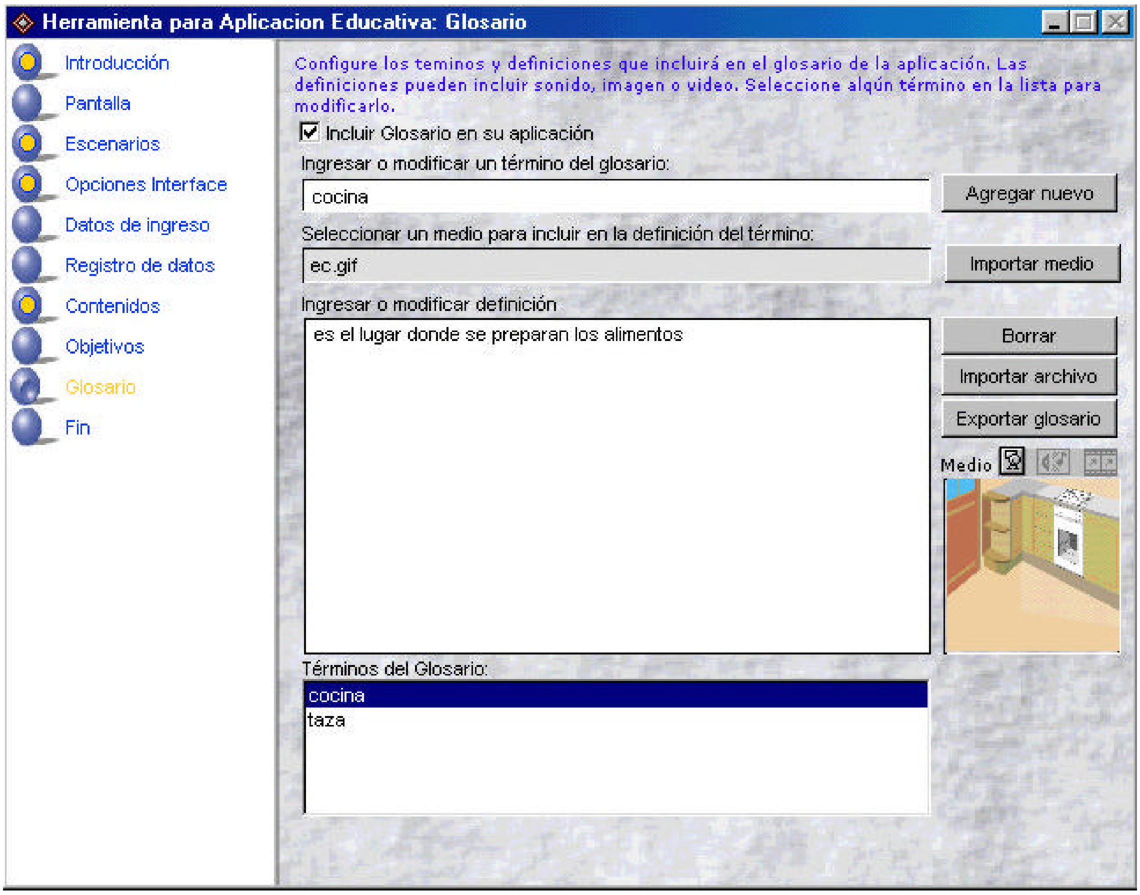


*Figure 1- Wizard to helps teachers in the construction of their own educational programs*

## 3-DESIGN THE MULTIMEDIA INTERFACE

The multimedia interface is the component of the ITS that interacts directly with the user. It includes the expert knowledge about concepts and representations of rules that describe situations of the real world.

The reason of including multimedia in this interface is the need of producing multiple and different sensorial stimulus. They are very useful to conduct and keep the attention of this particular type of children with special difficulties in learning process. [3]

The design of an ITS is strongly linked to the way in that knowledge is presented to the pupil. On one hand, it must be remarked that the main goal in the design of this system is to individualise the teaching process. In this sense, representation of the specific knowledge must be carefully considered. On the other hand, other fundamental goal is to achieve the instruction objectives. The degree of interaction between pupil and tutorial plays a fundamental role in the consecution of these instruction objectives.

Individualised teaching takes as starting point the determination of the goals and learning strategies from the particular characteristics of each student. The next step is providing the student with a list of tasks to complete. This set of activities will allow the pupil to acquire the goal concepts. The activities are designed according to the characteristics of the student, the learning goals and the available teaching resources.

### 3.1 Adaptive Presentation

The problem of finding an efficient way to transmit the knowledge by means of presentations adapted to the particular requirements of each subject is treated here.

The dynamic of the presentation is specified in a stage called construction of the presentation. This stage takes into consideration the characteristics and preferences of the user. Therefore, given a concept to teach, the information about the student and the learning goals, the presentation is composed identifying which media and styles are the most adequate to communicate the concept.

We have systematised the construction of the presentation using a methodology based in the formation of a sentence composed by a subject and a set of complements. The subject is the object under study, and the complements are the external elements related with the object such as the scenario where the object has been embedded or other objects in the proximity. The complexity of the task for the pupil can be controlled by changing these complements. This sentence is built dynamically according to the known specific features of the child and the learning goals. The particular object determines the media (static image, sound, video or animation).

Other important feature of this interface is the application of a random mechanism. This mechanism is used to select between different tasks to teach a specific concept. It is used to present random positive and negative reinforcement, and combination of different media to represent concepts.

In our case, knowledge transmission is carried out through different interactions between the student and a system composed of a computer and all the necessary complements that make possible the interactions. The complex task of achieving an efficient knowledge communication using an intelligent system can be summarised in the problem of instruction design for interaction and communication and using the previously determined interactions, which strategy is going to be followed to reach the proposed pedagogic goals.

Therefore, a tool as this one offers great perspectives from a pedagogic point of view because using of multimedia support together with AI techniques gives a way to adapt the system to the children specific needs. This adaptation is a basic requirement for children with intellectual and cognitive handicaps.

This interface has been validated and it has been demonstrated that children experiment great motivation when they work with this kind of multimedia systems. The proposed tasks are not perceived as a scholar work but as an interactive game. This fact increases their capacity to reach the proposed goals in the process of learning the presented concepts.

## 4- INSTRUCTION DESIGN

This section offers a conceptual framework for our instructional system design. Firstly, the learning styles and strategies considered in the instructional design are introduced. Thereafter, the principles of effective design that include Gagne's events of instruction are presented. Finally, the problem of how the students interact with the objects presented by the multimedia interface is described.

### 4.1- Learning styles and strategies

Many researchers in the field of education have begun to develop an understanding of student learning in terms of learning strategies. Such constructs represent behaviours and thought processes adopted by the student and are believed to mediate learning. At present, however, little is known of the impact that computer based learning technologies have on these strategies.

Learning styles are approaches to learning and studying. We all have learning preferences, which enable us to learn more effectively. When introduced into a learning environment that supports our learning style(s), learners have a higher level of understanding the material. The learning styles theory implies that how much individuals learn has more to do with whether the educational experience is geared toward their particular style of learning. In a traditional classroom environment, there is one instructor and several learners, which is an one-to-many relationship. The instructor presents information with his/her personal style of instruction. If the instructor's style of instruction is conducive with the majority of the learner's learning style, then the class as a whole will perform well. In the general case, the instructor's style is conducive with most of the learner's, but not a perfect match. In this case, the majority of the class will have an average performance with fewer people doing either very well or very bad, which establishes a bell shaped grade distribution [4].

Hence, the learner's chances of doing well in this classroom would appear to be significantly better than in a classroom with one instructor because each learner would adapt to the instructor(s) that would facilitate his/her learning style.

Increasingly, educators and researchers acknowledge that learning strategies comprise some of the active processes that need to be examined to gain a better understanding of how students learn. At the same time educators are turning to software developers to offer computer based solutions to material that has proved difficult or unsuccessful in the traditional educational setting. In turn software developers are utilising more sophisticated forms of media. Simulations have provided the student with a meaningful environment within which they can interact with physical objects or scenarios from the real world.

For many years educational researchers have sought to determine and understand the learning processes adopted by students. Much of this work has been influenced by psychological theory. In the last fifty years or so, the field of psychology has been dominated by an interest in cognitive processes. With this impetus and also an increasing understanding of personality and personality typologies, researchers began to investigate whether differences existed in the ways individuals approached everyday information processing. Differences were found which indicated a series of consistent approaches to the organisation and processing of information that came to be termed cognitive

As a construct, learning style generally referred to one of a finite number of learning dispositions that students adopted in their pursuit of a degree qualification. It also incorporated the notion of both cognitive and motivational processes impacting students' learning behaviour. For example, a student who was intent on gaining a high level understanding of the information being learnt and was motivated to do so by a personal interest in the subject matter could be categorised as adopting a deep learning style.

Learning strategies present a departure from this method, instead learning is seen as comprising a series of components or constructs that relate to motivational and cognitive aspects of learning behaviour. The student is seen as using each of these strategies to a varying degree, for example they might be highly extrinsically motivated and make good use of an organisational strategy.

We have considered the learning styles and strategies in the design of our instructional system. The set of tasks that are carried out to reach a particular goal is not the same for all the pupils, but it depends on the characteristics of each one of them. That is, the learning goals are defined for a particular student and a sequence of actions to reach these goals is considered. This is a search in a space of states, where only the sequences that leads to reach the proposed goal can be considered.

One of the subsystems drives the sequence of instructions and operates with the interface to guide the student through the set of tasks that are necessary to reach the learning goal. We have based this process in an event-based dialog: the actions of the pupil start the different tasks in the sequence. In this type of interface, the action of the pupil cannot be anticipated.

According to Robert Gagne, there are nine events involved in an effective learning [5]. Following this theory we have used in the teaching process the following sequence of events:

Event 1: Calling the attention of the pupil. We are basing this type of event in animated agents. The actions performed by the agent are of the type: calling the pupil by his name and presenting the problem. Other techniques that help in keeping the attention of the pupil are using colours determined by the preferences of the children and attention calls with sound and animations after certain time of inactivity.

Event 2: Giving some information to the student about the learning goals. The concept to be learned is previously described. Demonstrations of what the pupil has to do are also provided with each task.

Event 3: Giving some information to the student about previously learned concepts. The concepts to be learned are related to previously learned concepts.

Event 4: Presenting different stimuli. A concept has different ways to be represented (text, static images, animated cartoons, sounds, video). In the presentation these media are combined and also changed in order to avoid repetitive sequences related with a particular concept.

Event 5: Guided learning. The system makes uses of the agent to provide constant help along all the session. The agent introduces the context and explains what the pupils have to do. At the end of each task, the agent informs the student about the next tasks to do.

Event 6: Reporting the result of the activity. At the end of the execution of each task the results are evaluated and the agent communicates these results to the student using adequate representations of emotions for the failed or the succeeded tasks.

Event 7: Evaluation of the performance: At the end of the session a student progress report is given to the teacher. In this report several variables are measured: number of failed tasks, time intervals taken in solving the proposed tasks, repetitions and reinforcements that has been needed for solving the proposed tasks.

## 4.2 Interaction

Regarding to the interaction, the flexibility of computer software makes it possible for designers to provide service to users who have disabilities [6, 7]. For many categories of disabled people, computers may even allow for partial compensation of their handicaps [8]. The learning-disabled children education can be positively influenced by designing a special courseware that avoids on lengthy textual instructions, confusing graphics, extensive typing, and difficult presentation formats [9]. Sneiderman's studies reinforce the need for direct-manipulation of visible objects of interest [10].

The students interact with the objects presented by the multimedia interface, through direct manipulation of devices such as mouse, touch screen, speech recognition, … Therefore, an important part in designing the interaction between the student and the computer consists of selecting the hardware physical devices (mouse, touch screen, keyboard, light pen, ...) and the general style of interaction (software driven) that is more adequate for a specific individualised teaching. Exist five primary interaction styles: Direct manipulation, Menu selection, Form filling, Command language and Natural language.

We have selected an interaction style based on direct manipulation of the visual representation of the objects and actions. This has been described previously as the interface object-action model [11] and it is specially recommended for pupils that require a simpler and more immediate interface.

This model includes the universe of real-world objects. These objects play specific roles in the goals and actions of a user in the real world. We can say that each task can be decomposed in a number of actions. However, these actions are composed of a hierarchy of intermediate goals and individual steps. The metaphoric representation of the interface object-action is designed from the objects, elemental actions and hierarchy that take part in the described task. The interface should be designed in such a way that each elemental action appears clear enough for the user. In this way, the user is driven to decompose the planned task in a number of immediate actions.

An important aspect in designing an interface is building an information tree. In this task is important the role of the pedagogues. The educational contents are transmitted through an environment and a context. The environment has a graphic and conceptual representation, i.e. the metaphor. The events and their related contents are organised following a tree structure. The information tree is a way to represent the guidelines of a program both in its structural and dynamic aspects. The metaphor, the structure, and the functioning dynamic make a coherent universe both from the graphical and conceptual points of view.

Our system has three basic activities: teaching demonstration, evaluation and reinforcement [12]. These activities has presented by the Interface to the student according to individual preferences of each pupil taken into account the variables given by the Student Model and the learning styles as strategies given by the Pedagogical and Didactic Model.

# 5- CONCLUSION

In this paper we have described the instruction design that was implemented in an adaptive multimedia interface. The presentation changes its contents according to the particular needs of each handicapped student (pupils with learning difficulties). We have systematised the construction of the presentation using a methodology based in the formation of a sentence composed by a subject and a set of complements. This sentence is constructed dynamically.

In order to acquirement pedagogical knowledge we have developed a tool for helps teachers in the construction of their own learning activities. In the same time we have registered what activities the teacher carries out in order to explain a particular concept to a specific student, what goals he considers, what kind of media he utilises, and finally, what positive and negative reinforcements he applies after the result of the activity has been obtained. The logic flow has been used for representing the didactic model.

The KADS methodology has been chosen for designing the KBS part of the ITS. This had given us a structured way to represent the acquired knowledge.

There are many instructional strategies can be used in a learning environment. Effective use of these strategies permits students and instructors to actively engage in the learning process and develop positive meaningful relationship helps that build generative, interactive learning environments.

We have followed the recommendations of previous works in the area for deciding about specific components of the interface, for instance the interaction style and knowledge communication.

Specific modules of the designed system have been used in the Special School (ACAMAN) and in the association (Asociación de Trisómicos 21 (ATT21)) both of them in Tenerife. The presented multimedia interface has had a good acceptation both by children and teachers. Children see the activities presented by the system as a game, and the commentaries of the teachers were positive especially in relation with the possibility of designing their own multimedia materials.

## 6 - ACKNOWLEDGMENT

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