Games As Educational Strategy: A Case Of Tangible Interaction For Users Of Alternative And Augmentative Communication

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Abstract—**This paper presents an application formed by a series of games based on tangible interaction, using an interactive horizontal surface (tabletop), oriented to the educational context. The set of games has been designed for the special education scenario, and in particular, for the development of communicational competencies in users of Augmentative and Alternative Communication (AAC). The tool that groups the set of games is called ACoTI (Augmentative Communication through Tangible Interaction). ACoTI proposes that students, by using conventional toys, interact with the computer to perform various simple and complex association activities. Thus, the focus is to train and develop abstraction processes that favor the communication between the individual and his/her environment. In this case, toys have two essential roles: on the one hand, they act as mediators for individual-computer interaction, and on the other, they help to train students in the abstraction processes required for developing communicational skills. A detailed description of ACoTI is included in this paper, as well as the field work carried out to support its design and implementation, and the assessments carried out to validate both the application and its interaction mode. Initial results and possible future works are also described.**

Keyword: educational games; alternative and augmentative communication; tangible interaction

I. INTRODUCTION

Since this work is linked to the use of games in education, a brief description of the context will be done.

The term "game" can have at least two meanings. On the one hand, a game can be considered as a type of freely chosen or accepted recreational activity that is carried out to produce some kind of satisfaction. In this case, a game is considered to be organized by participating in a set of thoroughly defined rules that result in the creation of competitive and/or cooperative roles with other people or fluid interaction with objects. On the other hand, "game" can be used as a characteristic, as an adjective: “fun”, anything that is embedded with some game quality as an activity even if, strictly speaking, is not necessarily a game. In this sense, the highlight is on informality, competition or matchup, challenge, collaboration, creativity, etc. [1].

Therefore, a game can be defined as any culturally acknowledged format as well as any context or environment to which these formats are usually linked. Childhood education studies usually focus mainly on the first definition of game.

For many of these studies, children can explore, experience and test ideas through games. When children play, they learn about people and how to live with them.

This paper focuses on both meanings of game by considering not only the proposal of the game in itself, but also the context related to game-based activities, given its significance for special education, which is the target of the application presented here (ACoTI).

ACoTI focuses on people with significant language impairment and, therefore, difficulties to communicate. That is, people with “Complex Communication Needs” (CCNs) [2].

In the following section, the characteristics of the educational scenario typical of people with CCNs will be presented as well as some results obtained from the field work carried out to design ACoTI, taken into account the specific needs of this group of people.

II. FIELD WORK IN THE EDUCATIONAL SCENARIO WITH STUDENTS WITH CCNS. RELEVANT INFORMATION AND RESULTS FOR DESIGNING ACOTI

Before going into the specific features of the scenario targeted by ACoTI, we will present some useful definitions that will allow tackling and understanding the contents of subsequent sections.

Our starting point is a definition of communication that is related to the complex process of information transmission that individuals use to influence the behavior of “the others” [3].

The minimum unit of the communication process is considered to be the sign. A sign involves a representation (and therefore, an abstraction) mechanism of an aspect of reality, and it establishes various levels of complexity depending on the association between that part of reality and the construction of its concept (signified) and acoustic image (signifier). “Linguistic” or “verbal” signs are those that were created and

standardized (social convention) by a community of speakers. "No-verbal" signs are external to the linguistic system.

Human beings are capable of transmitting information of various types and through various systems [4]. Among these, speech is unquestionably the main one, although many other supplementary techniques are used in combination with it, such as gestures, actions, signaling, facial expressions, and writing.

Augmentative and Alternative Communication (AAC) is a clinical practice area that tries to compensate, either temporarily or permanently, the impairments of people with CCNs.

Augmentative and Alternative Communication Systems (AACSs) are intervention tools aimed at people with CCNs. The purpose of their design and use is teaching. They are based on a structured set of non-vocal codes, which may require physical support or not, that allow representation functions. Also they allow communication acts (functional, spontaneous and generalizable), either on their own or in combination with vocal codes or other non-vocal codes as partial support [5].

"Augmentative" Communication Systems supplement oral language when this is not enough to effectively communicate with the environment. "Alternative" Systems replace oral language when the latter cannot be understood or is missing. Both types of systems allow people with CCNs to relate and interact with other people, expressing their opinions, feelings and making personal decisions to lead and control their own lives. Ultimately, they allow them to participate in society with equal rights and opportunities.

High-technology AACSs are technological aides formed by peripherals, digital ramps and AAC software designed for people with CCNs. They are conceived as support tools for the development of communicational competencies and/or as "communicational prostheses" that help the individual relate to his/her environment [6].

Based on these definitions, we will now introduce some of the guiding ideas we have taken into account while designing ACoTI, based on the field work that has been carried out.

Before designing ACoTI, and in relation with previous research, field work was carried out at some educational institutions in Argentina that deal with the problems of people with CCNs. These activities focused on finding out the strategies, methodologies, and training processes used with this group of students to help them develop communicational competencies. Field work was structured in four phases, and the techniques used were participant observation, interviews, and surveys with key players in relation to the problem at hand [7][8].

Some of the aspects observed as regards teaching and learning methodology are as follows:

- Work is done in reduced groups: it is observed that in this context of special education, groups of students are reduced in size, depending on the personal characteristics of the members of the group. In the case of AAC users, groups include typically 5 students at most.
- Groups are formed based on levels: students are grouped not by age but by levels, based on their interests and competencies.
- The curriculum is adapted: curricular contents are the same as in regular schools, but with certain adaptations. Even though work is done in groups, teaching is personalized. Time is not standardized (there is no mandatory standard), the individual process required by each student to acquire knowledge is respected.
- Collaborative-type dynamics are established: the purpose is to train communication and dialogue among students, and these practices are essential to achieve this objective.

Additionally, field work has allowed establishing the following principles:

- The use of a high-technology AACS that allows seamless communication between the user and his or her environment is currently considered to be the ultimate goal of the training process for AAC. However, some of the institutions in Argentina that were part of our field work do not include a generalized use of this type of systems.
- Language and AAC teaching development phases articulate with those of the incorporation of a high-technology AACS; and the entire process takes place in the classroom where a number of aspects constituting the teaching and learning methodology specific to this educational scenario are established.
- The final instruction phase of AAC, called "Training spontaneous learning and interactive communication," is also the final phase for the incorporation of a high-technology AACS. During these, students develop progressively more complex communicational competencies, where the key factors are vocabulary identification, incorporation and expansion, communication practice type, and training dynamics for AAC practices.

To master this stage, students need to be trained in AAC practices that are mediated by computer technology and are suitable for the teaching and learning methodology typically used in this scenario. ACoTI has been designed to support these needs, and it is oriented to foster communicational practices and to collaborate in the use of a high-technology AACS, with the final aim of achieving autonomy in communication.

III. DESIGN OF ACOTI

ACoTI has evolved from its initial conception in accordance to successive assessments carried out in the original interaction scenarios. We present here the original idea and then, in Section 4, we will explain the main changes introduced as a response to the suggestions made by the teachers and therapists who assessed the tool, as well as based on the experiences with students and experts in this field.

Initially, ACoTI was designed as a series of computer educational games, based on four differentiating axes:

- Easiness of interaction through the use of every-day objects, rather than using conventional input devices.
- Possibility of collaborative group work with students with CCNs, respecting classroom dynamics.
- Using games as guide for training representation and abstraction processes, which are required for acquiring communicational competencies. This is based on the possibilities offered by the use of games in educational contexts.
- Teachers and therapists can set different configurations for the games such as abstraction levels used, based on the abilities of each student, vocabulary categories, etc.

The miniature objects used for interacting with the application have a dual role – they allow generating events and actions within the games, and they allow students to experience, through the different senses, the 3D representation of the objects, and then relate that to other representations and abstractions of the same object within the ACoTI software. Thus, students are trained in the abstraction processes mentioned before.

Each game offered in ACoTI is also designed to create an environment or context that fosters student motivation, collaboration, and the attitude required to learn, as stated in the Introduction.

The team that developed ACoTI worked in various aspects ranging from support (technical design aspects of the interactive table) to the design of the software tool oriented to the specific target group.

A. Technical aspects of ACoTI

ACoTI requires the use of a tabletop, such as the NIKVision model (specifically designed by one of the groups involved in this project) [9]. It is a horizontal active surface that allows interacting with educational applications by handling conventional objects on its surface (Figure 1).

For recognizing and tracking the objects placed on the table, Reactivision's framework software [10] has been adopted, which analyzes the image captured by a video camera placed inside the table. A printed (fiducial) marker is placed on the base of the object; it is used for interaction and it is identified by Reactivision software.

Only one conventional computer is required to run both ACoTI and Reactivision.

Figure 1. Examples of the interactive tabletops used in the project

B. Functional description of ACoTI

The various games that are included in ACoTI present a set of elements that students have to identify as related or not to the real objects they have. In general, different representations of the real object are used to help students learn the vocabulary of the sign systems normally used in Augmentative and Alternative Communication. The teacher or therapist can configure the system based on the language development level of the students, and the corresponding communication competencies they wish to develop.

A set of icons or symbols is projected on the surface of the table, all belonging to a core set of vocabulary terms organized in categories. The student has several objects that he/she can place on the table. The space on which each element should be placed is suggested either by means of an outline of the element (Fig. 2.a), the pictogram corresponding to its symbolic representation (Fig. 2.b), or the written word (Fig. 2.c). This will depend on the configuration selected by the teacher. The student has to associate the object (Fig. 2.d) with any of the corresponding representations that are projected on the table.

Figure 2. a. Outline of the object to be associated with the miniature object - b. Pictogram - c. Written word - d. Miniature object handled by the student

The interaction dynamics proposed by ACoTI for this type of games requires that the student completes the category by handling the objects, placing them on the space suggested in the graphical representation that is projected. Every time the student successfully places the object on the right space, there is feedback to reinforce learning through the use of auditory and visual effects.

By handling the miniature elements provided by ACoTI, the student "experiences" the object, he/she perceives it in all its aspects. Then, by identifying its representation on the graphic user interface, the process of creating meaning is fostered, since the student assigns meaning to the physical entity by building its concept and acoustic image. As the teacher configures the system for viewing increasingly complex signs, the student achieves a greater level of abstraction of the real object (see Figure 3).

Figure 3. Example of miniature objects and other possible representations for them.

Thus, ACoTI is a support tool for the abstraction of the real object up to its planar identification, which is a basic

communicational skill for acquiring language. Then, as different categories of AAC systems are added, the students learn and expand their symbol vocabularies that they will use to communicate. This process also motivates and stimulates students by using various multimedia representations.

ACoTI also offers other games that allow associating objects by colors and shapes, based on the development of some students who could be able to tackle this type of activity (see Figure 4).

Figure 4. Example of an associating colors activity

IV. ASSESSMENT OF ACOTI AND ITS IMPACT ON TOOL REDESIGN

The first assessment was carried out at a Special Education School in Spain [11]. Specialized teachers and professionals participated, as well as a group of students users of AAC. This first assessment phase focused on two aspects:

- Analyzing if the students could carry out abstraction activities with the games included in ACoTI.
- Analyzing, in a real context, the possibilities of interaction with the tabletop by the target group.

Additionally, observations were made to determine the level of comprehension of the students regarding the activity. This was done by direct observation of the students to see if they could tell when they had successfully finished the task and when they had failed.

The methodology used to develop this first assessment stage was as follows:

- Selection of the teachers and students that would be involved in the assessment, within the selected institution.
- Development of work sessions with teachers and students to use the technology being assessed.
- Application of observation techniques during these sessions in the real context, and subsequent analysis of videos and logs, at the lab.
- Conclusions and improvement opportunities. New plan to assess the results obtained in ACoTI.

Work was done with a group of 8 students in regular sessions. Their motor and cognitive skills were observed. The simple and complex association offered by ACoTI were used; these games require that a real object (or similar) be related to its planar representation.

The first type of educational game required students to relate an object with its outline. Then, other games were introduced, which, for example, required the use of colors. Pictograms were also used – students were required to relate the object with its picture, which was shown on the table.

Among the results obtained from these work sessions, the following should be highlighted:

1) As regards student comprehension and performance

- The students can perform successfully in association activities such as: object/outline, in cases of simple association (same number of objects and outlines). They have difficulty in complex association tasks (for instance, when they have a toy whose representation is not shown on the table).
- Students can relate pictograms with representations on the table. However, the show preference for using miniature toys for playing the games controlling the application.

2) As regards the use of the tabletop and tangible interaction

- It is natural for the students to work with the real or miniature object to interact with the software. They appear to be motivated and enjoy the activity.
- In the case of educational games that require different types of actions with the real object to control the application (i.e., it is not enough to simply place the object on an area of the table), interaction becomes more complex and less natural.

Since ACoTI is developed as part of a joint project between Argentina and Spain, the second assessment stage included the development of a series of group sessions with specialists and therapists in AAC in Argentina. This time, the purpose of the sessions was to analyze the possibilities offered by ACoTI in the context of special education schools in this country. These sessions corroborated that participants are very interested in including technology to the teaching and learning processes for this group of students. The possibility of working with ACoTI would impact the vocabulary acquisition processes in these students, and it would be good training for the use of Augmentative and Alternative Communication Systems.

Finally, an authoring tool that would allow teachers and therapists to generate games in ACoTI is also required. Even though the tool can be configured, this would imply advancing towards making it an authoring application that would allow generating various types of games. This opens a new road for the project, one that we are already exploring.

V. CONCLUSIONS AND FUTURE WORK

ACoTI is a tool that, through a series of (simple and complex) association games, accompanies special education students, in general, and Augmentative and Alternative Communication students in particular, while they develop their communication skills.

The assessment activities carried out have helped to establish the value of the design and development of this tool, and have allowed establishing what needs to be adjusted. As part of this improvement plan, we are currently redesigning ACoTI to turn it into an authoring tool to generate tangible interaction games for the special education context. This will allow teachers and therapists to easily design and create games to be used in their classes and specifically tailored for the needs of their students.

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