Use of a robotic platform in dyslexia-affected pupils: the ROBIN project experience

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Abstract**—**The ROBIN project was a joint effort that involved private and public entities, aimed to develop a computer-based software platform to promote a multi-faceted representation of data to build learning exercises supported with a feedback provided constantly by an anthropomorphic robotic system. The platform was devised in order to build a playful and stimulating learning environment able to support children affected by dyslexia.

Keywords**—** Dyslexia, teaching, robot-aided learning, learning impairment.

I. Introduction

THE ROBIN project, developed under the realm of Apulian Living Labs [1], creates a multimedia robotic system integrated with the OMNIACARE software platform, developed by eResult, that enables to cope with the miscellaneous disability-related conditions. Among the different types of disabilities, the SLD – Specific Learning Disabilities take on great importance and among them in particular the ones related to dyslexia disorders.

"Dyslexia" is a specific difficulty that refers to the ability to read accurately and fluently and which is often characterized by poor writing skills. The dyslexic subjects have great difficulty in learning to read: reading is slow, laborious, and usually inaccurate. The ability to read is hard to achieve as it implies repetitive tasks, therefore it requires a major investment of cognitive resources [2].

Reading disability affects about 3-5% of Italian children [3] and it is the most prevalent of all learning disabilities. Developmental dyslexia is diagnosed by specific difficulties in reading that cannot be explained by causes related to intelligence or lack of educational opportunities. Literature prove the usefulness of Information and Communication Technologies to support dyslexic pupils in learning tasks, but often such technological tools are developed to be used in one-by-one rehabilitation treatments, hardly usable in the context of a teaching class [4, 5].

ROBIN, by means of OMNIACARE-based exercise platform, develops a playful and stimulating environment able to support children affected by dyslexia not only in the cognitive stage in order to facilitate their learning activity, but also and particularly in their relational and growing path [6].

II. Technology

The goals are pursued through the use of a kit consisting of an anthropomorphic robot, NAO, developed by the French company Aldebaran Robotics. NAO interfaces with a laptop and an LMS - Learning Management System platform, OMNIALEARN, hosted on a remote server – OMNIACARE – accessible via the Internet and capable of recording all the performance data of the exercise. The OMNIACARE platform, specifically developed for the remote monitoring and assistance of frail users, has been extended in order to communicate with the robot and to make use of the different sensors and devices whom it avails of to implement specific algorithms that enable a multidimensional representation of the information. NAO is a hi-tech robotic device characterized by 25 degrees of freedom, which allow it to perform even the most complex motions and it is suitable for structured and unstructured environments. It is equipped with:

1) Ultrasonic proximity sensors pointing towards different directions, that allow to detect and evaluate the physical distance
2) Pressure sensors located under the lower limbs
3) Advanced multimedia system with 4 microphones and 2 speakers
4) 2 CMOS cameras designed for speech synthesis, space location, face and object recognition
5) Interaction sensors such as 3 touch areas above the head of the robot
6) 2 infrared led and 2 contact sensors on the front of the lower limbs

III. Methodology

The ROBIN system and the services it provides have been

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shaped according to the UCD - User Center Design methodology. It is a design philosophy and a process, which focuses the attention on the user's need, expectations and limits in respect to the final product. The user is placed at the center of each step of the development process in order to maximize the usability and acceptance of the product, optimizing it around the needs of the users. The UCD methodology is characterized by a multi-level co-design and problem solving process. It requires designers not only to analyze and foresee how the user will utilize the final product, but to test and validate their assumptions at the same time by taking into consideration the end-user's behavior during the usability and accessibility tests (test of user-experience) into the real world. The UCD methodology leads to the creation of the final product through an interactive process that provides the development of a first prototype and a following test and assessment stage, on the basis of which to proceed with the development of the next prototype. Each cycle therefore leads to the creation of a product that is closest to the real and practical needs of the user.

IV. Analysis of Users

Although over the last twenty years much hardware and software for education has been tested and produced, even for students with special needs, it often have been developed without a real and critical analysis of the user needs. The starting point of ROBIN, however, was just that: the desire to explore and embrace the experiences, attitudes, expectations and needs of technology of the school community [7]. To explore the problems and potential of ICT in support of learning processes with dyslexic students, the survey technique of focus groups (FGs) was used. This is a special type of group interview that is designed to produce data on a specific topic by comparing participants [8].

The comparison between the clusters of focus groups conducted with groups of adults (A, B, C, E), has also highlighted three different macro-narrative categories.

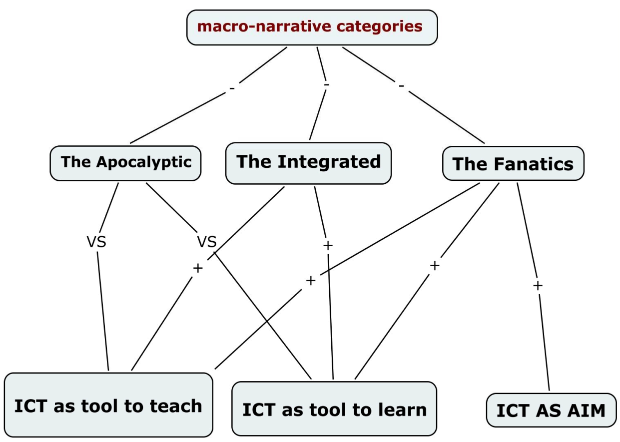

Fig. 1 Types of users

In the focus groups with adults, four meaning cores emerged about the function of the interaction with ICT and with the NAO robot. Discussion in the focus groups concerned these cores and went through an analysis in terms of expectations and critical aspects. In the first case *desiderata*, in the second one suggested solutions to some of the problems emerged.

The results of the focus groups have become the guidelines for the development of the LMS. The LMS platform provides three main categories of work, each with three different types of activities. Each activity is calibrated to three school levels: first cycle of primary school, second cycle of primary school, first cycle of secondary school. For each school level, all activities are scaled on at least three levels of difficulty.

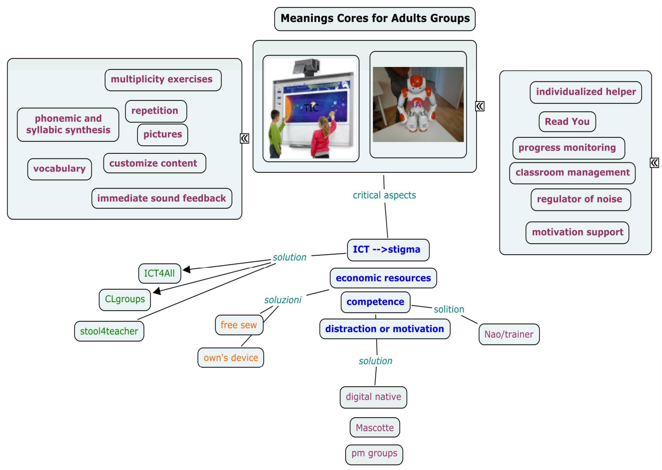

Fig. 2 Map of the results for the adults'focus groups

V. Activities

The platform provides exercises to the pupil, accessible via a PC or notebook. During the execution of the exercise, children benefit from motivational hints by the robot. The robot through automatic pre-set questions verifies the pupil's understanding level and returns positive and/or reinforcement feedback. By doing so, the pupil increases its own autonomy and perceived self-con• dence and gets strong sensation of grati• cation.

Three categories of exercises have been devised:

1) Didactical games. These exercises consist of simple games shown on screen with questions that require answers on the computer by the student. The level of difficulty can be configured and adapted by the teacher to the single student, based on age, capability and specific impairments. The first game proposed is "memory", through which the student has to find couples of the same cards, that can contain text or images. At any trial, and from time to time, the robot will give feedback and encourage the pupil. The second game is "rhyming", through which the student has to detect words in rhyme for a list shown on the screen. In this case also, the robot will give feedback and encourage the pupil. The third game built in the platform is "syllabizing", through which

the student has to count the number of syllables in a list of words proposed on the screen, while the robots provides feedback.

2) Reading comprehension. These exercises are defined with the Gullpease evaluation index of readability. They are devised with the possibility to hear reading suggestions by the robot or by the software platform. This category of exercises is currently under development, as it involves a considerable effort by programmers. The first example of exercise allows the teacher to define a text and then to put grammatical and semantic errors on purpose, so that the student will have to find out and correct them (with the help of multiple-choice list), while at the same time getting feedback and hints by the robot. A second type of exercises consists of a text with missing words in it, that the student will have to fill in, choosing in a list of multiple choices. The system will provide feedback through the robot and help the pupil in selecting the correct answer. A third type of exercise exploits conceptual maps. The teacher will input a text in the system and define the most significant words in it. The student will have to read the text through and, each time a significant word is spoken, the system will highlight it on the screen and progressively build the map in order to help the pupil understand the concept behind the text. The exercise is carried out with the robot speaking after the pupil.
3) Visual-spatial understanding. These exercises still require definition. The concept behind them is to help pupils affected by dyslexia to associate 3D situations to 2D animations, in order to fill in the gap to project two-dimensional images in three-dimensional patterns. An example of such exercises may be the design of a maze on the screen with the robot trapped in. The pupil must work the robot's way out of the maze and, each time a movement in made on the screen, the robot on the floor beside the computer table replicates it.

VI. Study

The project in the final step has been tested with some of the children guests of the cultural association, project partners. The CNTHI (Center for New Technologies for Handicap and Integration) at University of Salento has instead followed an assessment by teachers specialized in teaching children with specific learning disorders. The evaluation was carried out after a demonstration session of the platform with and without interaction with Nao Robot and was carried out through a survey using a questionnaire with Likert scale. It consisted of 28 open and closed questions designed to identify:

1) The level of acceptance of the proposed activities
2) The level of appropriateness to the user
3) The level of usability for the class
4) The system usability, interface synthesis and feedback, pleasantness of the system

The total score of the 4 areas was planned for a maximum of 140 points (28 questions with a score from 1 to 5 min max)

Analysis of the questionnaires showed that the average score is equal to 66.41. In general, the responses to the questionnaire and the observations made in the open-ended question, expressed enthusiasm from teachers for technology products that can support the dyslexic student in the class activities and that can be integrated into the teaching curriculum. .

Despite the large production of specific software, the teachers' point of view highlights the need to get commonly used products, which on the one hand avoid the stigmaarising from the use of "special" tool or on the other hand slow down the teaching process. The need expressed, therefore, is perfectly in the same way with the indications of the culture of inclusion and special normality (Ianes D. 1999) [9] and that proposed by the model of Universal Design for Learning (Rose, D. Meyer, Anne 2000) [10]. About the LMS platform used with Nao interaction, particularly liking was attributed to the use of the humanoid robot.

The development of automated agents to support learning processes showed results that follow the literature (Lester, Converse at all 1997) [4]. They had positive effect on the response and engagement by users when they can interact with the robot, and that through some main features: some belonging to the robot and devices, others belonging to the interaction model implemented. For the former, robot mimic, movements made, and the lights associated with emotional expressions. For the latter, what the robot said during the exercises, adverbs, adjectives, encouragements, used as feedback to the performance of student.

The emotional-affective dimension is one of the things that the scientific literature on specific learning disorders gives due consideration to, because students often develop behavioral problems and relational complex as symptoms related to the disorder, because of the discomfort experienced in the classroom. Many children with learning disorders present inadequate non-verbal behavior in the social sphere; these difficulties have to be related to the limits shown to encode signals and non-linguistic indices of human behavior and the use of feedback in interpersonal relationships (Valeschini, Del Ton, 1981) [11]. In this regard, Rourke took into consideration the lack of adaptation and socio-emotional deficits common to many children in this particular diagnostic category, outlining some possible causes of difficulties in social interaction (P B. Rourke, 1993) [12].

The computer is an important tool because it can both motivate and because it allows more elaborate and sophisticated exercises than those with paper and pencil. Robotics has also been used to meet the needs of social interaction for the elderly (Wada et al. 2002) [13] and children acting as a catalyst for social interaction (S. Turkle, W. Taggart, CD Kidd, O. Dasté. 2006) [14]. Children with non-verbal learning disorders in particular may face difficulties if not supported by a specific intervention aimed to learn to deal with the visual, spatial, praxis, rather than how to use computers (Vio and C. Tressoldi PE 2002) [15]. Therefore, one of the conclusions that have been reached through the experience made with the ROBIN project, is highlighting the role that ICT can play in the global care dyslexic student, not only from a technical learning reading (phono-syllabic, and visuospatial tasks), but also on the emotional and relational aspects.

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