Playful Learning for Kids with Special Educational Needs

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Abstract. It has been verified that today in the Italian schools there are about 15–20% of students presenting different kinds of "Special Educational Needs". In order to respond to BES, the schools follow the Customized Learning Plan (PDP), a useful tool for designing operational models, strategies, systems and learning criteria for each student. For the various operators involved in the treatment of the disorders and also for the parents, it is of great importance to have adequate, efficient and flexible support tools that respect the desires and the enthusiasm of children of different age, without creating additional psychological and social discomfort. This research presents a particular relevance focus on the issue of management of entertainment and playful learning through digital systems offering a 'playful interaction'. New concepts of 'game' and 'device for interactive activities' offer screen-based compounds to scenarios on the relation between user and device, including physical activities or integrated physical gestures, which relate the observation of screen to the physical reality.

Keywords: Interaction design · Product design · Playful experience

1 Learning Disorders and Technology

The Developmental Disorders Specific of Learning (DSA) are an area of clinical interest in which over the last thirty years an important advancement of knowledge has been achieved thanks to the numerous contributions derived from scientific research and the refinement of diagnostic investigation techniques. This allows today to be able to share the definition and classification of DSAs also among professionals and/or specialists of different backgrounds (psychologists, neuropsychiatrists, speech therapists, pedagogists), allow to make a diagnosis accurately and plan a targeted treatments.

Hammill defines the general characteristics of Learning Disability (LD) as a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening skills, oral expression, reading, reasoning and mathematics,

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presumably due at dysfunctions of the central nervous system [1]. In short, it deals with a diversified range of problems in cognitive development and scholastic learning, not primarily due to factors of severe mental handicap and definable on the basis of failure to reach expected learning criteria (for which there is a broad consensus) to the general potential of the subject [2].

These are usually difficulties that occur in the child from the early stages of his learning, when he must acquire new skills such as reading, writing and calculating, starting from a neuropsychological structure that does not favor the automatic learning of these specific skills. The evolution of these disorders, in fact, is favored by the precocity and adequacy of the intervention, as well as by the compensatory measures taken in the context of the scholastic pathway to encourage learning and for a favorable prognosis regarding social development and of the personality of those who present these problems.

These considerations, in recent years have also led Italy to focus on prevention, developing programs to strengthen the prerequisites of basic school learning to be used starting from kindergarten.

1.1 Relationship Between Technology and Teaching

Technology has already revolutionized our lives: from the way we work, to the way we shop or travel, just to name a few. It can therefore certainly change the way we study and acquire new knowledge. Human computer interaction is widely considered an integral component of many education and training systems at various levels of technology access [3]. An example is the Edugames: these in fact allow students to learn more actively than traditional educational methods and allow them to have fun while learning something new.

To date there are many studies that support the positive role of video games in the future of learning, thanks to their infinite potential. Of the many education and training systems developed in recent years, one of the most intensively studied is interactive computer game-based learning systems, which have been developed and applied in many teaching-learning activities, especially for children and adolescent learners [4, 5] because children in these age groups are intrinsically motivated to play games and often lack interest or motivation in their courses [6]. Studies show that the key factors in user acceptance of these systems are perceived ease of use, perceived usefulness, self-efficacy, and satisfaction [7].

2 Design of ‘1,2,3 Stella!’ App

One of the main objectives of this project was to propose a valid alternative to what is already present on the market, in the field of apps for speech-language use. The multidisciplinary team has in fact conducted a careful preliminary analysis on the products currently on the market, evaluating different aspects of the applications. The study was supported by the NuovaMente Children’s Diagnostic Center team, which includes child neuropsychiatrists, neuropsychologists, psychotherapists, speech therapists, pedagogists, learning tutors and educators.

The apps chosen for the analysis have been divided into three categories according to the type of use: specific apps for the treatment of speech therapy, non-specific apps, but which are used for some speech therapy treatments, apps with only a game goal. The app evaluation criteria were:

- Usability of children;
- Enjoyment (ability of the app to entertain and enjoy the child);
- Feedback for adults;
- Adaptability (set activities according to the different needs of the child);
- Interface design;
- Therapeutic suitability.

From this analysis it is possible to draw different conclusions. First of all, the specific apps for speech therapy are without an adequate graphic interface, even if they are valid for the speech therapy treatment to be adopted.

It has also been noted that many app for speech therapy treatments there are no the possibility of adapting the exercises according to different needs.

The game app, finally, provide a well designed and edited graphics, aimed at the fun of the child, of course, however, are not effective for treatment.

2.1 Difficulty in Learning and Mathematical Prerequisites

The work concerns the development of an app to aid the speech therapy treatment of children with difficulties in the prerequisites of the logical mathematical area[1]. This app, therefore, was created with the aim of enhancing the prerequisites of the logical-mathematical area that are weak in preschool children and to prevent the presence of a future DSA related to the world of computing, namely the Discalculia [8].

The prerequisites are a series of basic knowledge for school learning that the child should develop in order to easily continue on an educational path that reflects the normality [9]. For the kids is important to have and exercise this knowledge from the last year of the Infant School, so as to facilitate entry to the Primary School. The target is in fact represented by children aged between 4 and 6 years.

Instead, by numerical intelligence we mean "the ability to understand, interpret and reason through the complex cognitive system of numbers and quantities", that is to say, to be intelligent through quantity [10]. Some psychological studies have established that it is an innate ability in human beings (and not only), which are then born predisposed to numerical intelligence as to the verbal [9]. However, only some numerical skills are innate (ability to "see" a quantity in the right way), the others are cultural (ability to associate the quantity to the correct name) the ability to estimate [13].

[1] The project stems from the collaboration between Benedetta Terenzi, PhD and a contract professor at the Design Campus, scientific advisor and coordinator of the team, with Pierluigi Crescenzi, full professor of the Department of Mathematics and Computer Science 'Ulisse Dini' of the University of Florence, with the Children's Diagnostic Center Nuovamente (Firenze) which includes the speech terapist Elisa Cangialeoni, Ilaria Tilli, Giulia Filippi. The app is developed with the help of graduate in Computer Science Nicolae Puica [11] and the graduate in Industrial Design Martina Denti [12].

According to 2015 data from the International Academy for Research in Learning Disabilities (IARLD) 2.5% of the global school population presents difficulties in mathematics in comorbidity with other disorders, while 2 children in 1000 have severe Dyscalculia. The MIUR in 2015 calculated that in Italian schools, between state and non-state, of every order and degree, there are 186,803 students with learning disabilities and of these, 41,819 suffer from Discalculia.

2.2 The GUI Design

For the design were followed the heuristic principles of usability described in the decalogue of Jacob Nielsen, deriving from the application of factorial analysis techniques on usability problems. The app has been designed with a friendly graphic user interface (GUI), with the aim to have an instrument very simple and intuitive, for all the users. In fact, the app has provided different levels of use for the three different users. A coherent graphic layout was maintained in the different sections and within the different activities. In this way the different users do not feel disoriented in changing the sections provided by the app.

For the use by adults, have been inserted the recognizable commands now universally recognized used in other apps or websites, such as registration procedure 'new user' or 'log in', etc. For the icons and the bottom functions have been chosen very intuitive and easily understandable specifications.

The adult user has control of the information content and move freely between the various topics. The child user, on the other hand, deliberately follows only guided path. The registration procedures and the choice of the avatar can be skipped and resumed at any time. On every screen of children's games there are the commands 'exit' and 'help' have control over the activity.

Parents and children have access only to certain functions, chosen from time to time by the speech therapist. The children can only perform the activities activated by the speech therapist. During the activity by the children, in addition to the sound feedback there are some positive vocal feedback ("Good job!", " Keep it up!") Or negative ("Come on, try again!", "You're almost there!"), which serve to stimulate the child. The parent can monitor the activities performed by the child.

Speech therapists have a great deal of opportunity in choosing parameter settings for the child's activities, depending on the needs. They have also mission diaries and activity reports with very precise data indications, which can be used to produce accurate patient improvement graphs. All informations are saved in a cloud storage, accessible and manageable by the speech therapists.

3 IT Development of the App

The proposed app has been developed within the Corona SDK framework [14], which is a development environment that allows programmers to develop multi-platform apps by using LUA, a language supporting procedural, object-oriented, and functional programming language [15].

This framework is quite easy to be used and, most importantly, it allows the deployment of the app for different mobile operating systems, such as Android and iOS. Moreover, Corona SDK is widely used for the development of 2D games, and it supports several features which turned out to be very useful while developing our app (such as efficient management of animations, audio, and images).

This app makes heavy use of images at high resolution and the Corona SDK facilitates the management of such images by supporting the so-called *image sheets* which allow the programmer to load several different images from a single larger image file. To this aim it is sufficient to specify the width and the height of the global image (called *sheet*), the number of images contained in the sheet, and the width and the height of these images.

Corona SDK also allows the programmer to easily deal with *JSON* (JavaScript Object Notation) files. JSON is a simple standard for formatting and exchanging data, independently of the used programming language [16]. In our app, we used JSON in order to store all the local settings of a game, such as the ones we are going to describe in this section.

Finally, Corona SDK easily allows the programmer to manage a SQLLite database. SQLLite is "an in-process library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine" [17]. In our app, we make use of a SQLLite database in order to globally store the activities of the children: the contents of this database are successively elaborated in order to evaluate the performances of the children themselves.

The app starts from the home page shown in the following figure, in which planets and stars rotate and a background music is played (from now on, we will avoid to specify that the app includes animations and sounds).

The ACCEDI button allow the children to access a centralized system, in order to record the activities and the results of the children themselves. The IMPOSTAZIONI button allows the parents or the therapist to change the settings of the game according to the following criteria.

1. How many exercises the children have to solve.
2. Focusing to a specific range of numbers.
3. Focusing on a specific subset of numbers.
4. Allowing the possibility of hearing an audio communicating the number to the children.
5. Selecting which kind of association the children have to perform: from decimal numbers to dot numbers, from dot numbers to decimal numbers, or both.

These settings are stored within the app and remains valid until the parents or the therapists decide to change them.

The GIOCA button of the home screen starts a new game, which is a sequence of association exercises in which the children have either to choose, among the three possibilities shown in the lower part of the screen, the decimal number corresponding to the dot number shown in the middle of the screen, or to choose, among the three possibilities shown in the lower part of the screen, the dot number corresponding to the decimal number shown in the middle of the screen (Fig. 1).

Fig. 1. App Home page

This second kind of exercise can be easily adapted to the integration of the app within a product-based screen-based interaction environment. Indeed, a prototype of such an integration has been realized by substituting the act of clicking on the correct button by the act taking a cube and facing the right face of the cube towards the screen (see the end of the next section).

As we already said, Corona SDK facilitates the task of including audio and animations in the app. Indeed, we used these features both for playing some background/feedback music and instruction audio files and for animating some drop-down menus (Figs. 2 and 3).

Fig. 2. App setting page

Fig. 3. App gaming page

4 Playful Interaction: Screen-Based E Product-Based Design

The year 2007 stands the launch of first IPhone [18]: this innovative product-system is working through innovative interface, avoiding traditional typing system and using innovative software able to transfer into the mobile system a real user-centred device. Moreover, the use of internet becomes continuous, not only a occasional need. Them the digital devices invade the user daily life, generating screen-addicted behaviours and consequent disorientation.

In parallel, within the international research context, we highlight a new interest about interaction design topics on product design and linked services aiming at avoiding monothematic researches on screen-oriented solutions. In fact, these studies develop product-based solutions connected to screen-based interaction design frameworks [19]. Then, following this design process, we have information and communication systems, sharing tools and interaction platforms not based only on a screen interface, but mostly supported from the performances of a 3D artefact.

Following this perspective, the product becomes a device aiming at improving the physical wellbeing and the quality of life, in a functional and aesthetic sense. Within the REI lab [20] of Design Campus-University of Florence set Care Device workshops programs, the research sessions focus on innovation done by embedding micro-technologies to the artefact, adding new steps of the product values chain. In addition the Care Device Workshops define a clear design framework on interaction design research connecting medical matters and the focus on shapes or psychological topics to semiotics.

According to Universal Design criteria [21, 22], the research process aims at connecting the design disciplines to the medical/paramedical care. In particular, this bridge is established through technologies embedded into the product. These applications evolve the artefacts to product systems including sensors, identification technologies, smart materials, becoming an auxiliary device to improve the user psycho-physical status.

The workshop set design-systems through user-friendly microcontrollers, composed by a hardware component (digital card) and specific software. The user-friendly sensors allow the researchers to run a proper prototyping and a fast learning about electronics and programming foundation. The digital sensors are high-precision tools that aims at changing a physical phenomenon (from environmental factors or from the contact with the user body) into a numeric value. Through a proper script on the microcontroller on the digital card, the input numerical values could be processes and interpreted to have a final output (digital or analogical). So, we define "learning by prototyping" process, in which we can experiment design solutions to implement realistic interaction frameworks in between user and device.

4.1 Design Methodology: Designing Devices Including Screen-Based and Product-Based Interaction

The workshop path aims at defining differences and contact points in between design disciplines and the medical/paramedical care, implementing the instances emerging from the medical research through the product-system performance. So the design project is a tool to express the medical/paramedical therapies and advices, on the other hand the medical research is a highly significant support for the interaction design performance. Then, the curative approach on specific disease or user functional problems stands in relation to design topics relating to the morphology, technology and interactive aspects of the product system.

The workshop program presents a design methodology according to specific user scenarios, following steps:

(Phase 1)

(A) Selection of the pilot subject according to medical/paramedical requests;
(B) Benchmarking analysis about other product or product-systems already existing in the market; highlighting on possible technology and design transfer from already existing product (even not in the same product area);

(C) Defining through a scenario-based design [23, 24] process the design concept and the interaction storyboard;
(D) Selecting the proper technologies to be embedded into the artefact.

(Phase 2)

(A) Design project development of the device and product-system;
(B) Prototype development.

(Phase 3) Evaluation session

(A) Interdisciplinary focus group to evaluate the design results and related interactive model [25];
(B) Prototype test, by simulating the user scenarios, supported by videos about the interactive performance [26, 27].

4.2 Screen/Product Based Interaction: Sensea [28] Microcontroller

Sensea microcontroller is an interactive platform that allows not expert users to create automations in a easy and fast way, avoiding complex trainings on electronics and programming systems.

Seansea is composed by smart electronic circuits able to communicate through new radio waives technologies, getting a high good level of communication without a high energy consumption. Microcontroller's power supply is provided by rechargeable batteries, working through Wireless Power Transfer [29] technology.

Case History (1): MooMi project

Project by Sara Foriglio/supervisors Gabriele Goretti (interaction design process), Michele Tittarelli (Max/MSP)/Scientific supervisor Elisabetta Cianfanelli

Internet addiction disorder is a clinical problem caused by the non-control of impulses. IAD could rise in different ways: cyber-sex addiction, social network addiction, compulsive online shopping, videogame addiction or information overload stress.

Moomi project is composed by four toys-devices and by a dedicated screen-based app. These devices interact to the user in different ways: "Ted" fills with stains, "Ned" moves it self as if it melted, "Bill" stretches as if to fall asleep, "Carl" bends his head to one side. These visual feedbacks are activated progressively according to the time spent in front of the computer. Each Moomi toy embeds a proximity sensor aiming at counting the minutes spent in front of the screen. These playful tools provide a self-analysis support as for IAD users as for professionals who spend most of their time in front of a monitor.

Case History (2): Usignolo project

Project by Ilaria Forzoni/supervisors Gabriele Goretti (interaction design process), Michele Tittarelli (Max/MSP)/Scientific supervisor Elisabetta Cianfanelli

The voice may experience disabling vocal difficulties such as dysphonia (more or less severe vocal changes) that can result in organic lesions if correct vocal behaviours (vocal hygiene) are not used.

Usignolo project is an interactive device that allows the user to adjust the volume and tone of his voice in an optimal way: the values coming from the internal microphone are tested by the software that adjusts the intensity of the feedback based on the volume expressed, allowing to correct the volume itself (depending on the program set). Though a dedicated web site and app, it is possible to review the daily records, that could be evaluated by specialists of pathologies related to the voice.

5 1,2,3 Stella! Product-Based Prototype, Final Considerations

1,2,3 Stella! App and Care Device workshop program represented a very significant opportunity to implement a direct connection in between screen-based user experience and product-based interaction. As described in the Care Design tool as in 1,2,3 Stella! App as in Care Device devices (i.e. Usignolo case study) we establish a communication in between design disciplines and medical/paramedical studies (Fig. 4).

Fig. 4. Developing interactive scenario for 1,2,3 Stella! product-based interaction.

The prototype we are developing integrates with the existing app (described in Sect. 1.1) in a quite natural way. Since the activity requested to the children is to select either a decimal number or a dot number, we allow the children to perform this activity by taking a dice from the table on whose faces is represented the decimal number or the dot number. In other words, the prototype uses twenty little dices, one for each decimal number between 1 and 10 and one for each dot number between 1 and 10. Actually, the developed prototype currently includes only six dices representing the numbers between 1 and 3: this implies that in the settings of the game, the parents or the therapists have to tell the app to focus on the subset of numbers between 1 and 3. Whenever a dice is taken by the children, the micro-controller hidden within the dice will communicate to the app which decimal or dot number has been selected by the children. The app will respond to this interaction as if the children had clicked on the corresponding decimal/dot number on the screen.

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