Playful Learning in Smart Spaces for Children with Intellectual Disability

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ABSTRACT
Our research explores the role of "smart objects" and "smart spaces" in game-based learning for children with severe intellectual disability. The paper discusses the approach and the preliminary results of the P3S (Playful Supervised Smart Spaces) project, and offers some reflections on the equation "Learner as Player" for this specific target group.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: Multimedia Systems, User Interfaces

General Terms
Design, Experimentation, Human Factors.

Keywords
Full-body interaction, smart objects, smart spaces, children, intellectual disability

1. Introduction
In recent years we have witnessed an increasing development and adoption of interactive learning applications for children with Intellectual Developmental Disability (IDD), such as children with Autism Spectrum Disorder – ASD, Attention Deficit Hyperactivity Disorder – ADHD, Down Syndrome, or Schizophrenia. These disabilities are characterized by significant limitations both in intellectual functioning, i.e., general mental capacity such as memory, attention, reasoning and problem solving, and in adaptive behavior, i.e., social and practical skills related to daily living (interpersonal relationships. social responsibility, ability to follow rules/obey laws, or personal care).

Existing applications for IDD children exploit a gamut of conventional as well as "beyond the desktop" technologies and devices, including haptic controllers, (multi)touch small and large displays, digitally augmented physical objects, digitally enhanced physical objects, robots and motion-sensing cameras [1, 2, 3, 5, 6, 9].

These tools implement different learning approaches, to address the specific learning needs of each specific type of IDD. Still, most of them share at least one common feature: they adopt a *game-based paradigm*, i.e., they attempt *to make children play while using technology*. The reason for this design approach is somehow obvious. Play is the most natural way for any young child to express him/herself, to experience and make sense of the world, to connect with other human beings, and ultimately to exercise and develop the core cognitive functionalities that are a prerequisite for any higher level skill, e.g., imagination, language development and abstract reasoning [8]. In addition, play is fun, and fun accelerates learning processes by inducing a state of flow that promotes attention, increases the capability of selecting relevant information, and augments the willing to complete the required tasks. Integrating digital play into educational routines offers opportunities for encouraging social interaction, developing communication and imaginative thinking, and increasing children's ability to perform a variety of activities needed for daily life. Finally, gameplay deficits are often used as "markers" to detect IDD or to evaluate it, as gameplay is one of the areas of development most significantly affected by cognitive and emotional impairments.

Our research explores the role of "smart objects" and "smart spaces" in game-based learning for children with severe intellectual disability. In this contexts, the paper discusses the approach of the P3S (Playful Supervised Smart Spaces) project. It also offers a reflection on the equation "Learner as Player" for this specific target group, reporting some lessons learned from P3S design and ongoing evaluation activities.

2. The P3S Project
The Playful Supervised Smart Spaces (P3S) project, supported by the European Institute of Technology (EIT), started in January 2015 and will be completed by the end of the year. It aims at providing new forms of learning and behavioral therapy for children with severe intellectual disability) by offering novel multisensory and multimodal "smart spaces" that can be used at health centers, special education institutions, and home.

From a learning perspective, P3S is grounded on theoretical and empirical research in psychology, pedagogy, and neuro sciences that pinpoint: i) the relationship between physical activity and cognitive processes, with the formative role of "embodiment"[1] in the development of cognitive skills [4]; ii) the potential of light in promoting people relaxation and well being.

From a technological perspective, P3S general approach implements, and extends, Mark Weiser's vision of a smart space as "a physical world that is richly and invisibly interwoven with the sensors, actuators, displays and computational elements embedded seamlessly in the everyday objects of our lives, connected through a network". In addition, P3S exploits an IoT (Internet of Things) paradigm, as all components of P3S smart spaces are Internet-connected (via a dedicated P3S platform).

P3S smart spaces are characterized by an innovative combination of *smart objects* (toys or everyday items digitally enriched with sensors and actuators), *virtual worlds* on large screens, and *smart*

[1] Embodiment is defined as the way an organism's sensorimotor capacities enable it to successfully interact with the physical environment.

lights, which are orchestrated as a continuous UX space. Using multiple forms of full-body interaction — physical manipulation of objects and movement/air gestures— children can control and play with smart objects and on-screen virtual worlds, while smart lights (either integrated in the ambient or embedded in the objects) dynamically adapt themselves to the user experience, providing engaging visual feedbacks and creating a relaxing, comfortable atmosphere.

Figure 1 provides examples of P3S smart spaces while a video presenting the project and children's play activities is available at https://www.youtube.com/watch?v=JZ-1Ks7LQcs&feature=youtu.be

Figure 1: Examples of P3S Smart Spaces

The IoT approach enables the automatically gathering of behavioural data while children interact with P3S smart space elements. These data are stored on the cloud and a set of dedicated cloud services enable specialists to exploit them for analysis, research, and therapy purposes, or to remotely customize the characteristics of the smart spaces to the specific needs of each child.

By adopting P3S smart spaces, learning and therapy institutions can offer new forms of game-based learning and behavioural therapy, as well as new services that can mitigate the patients' burden of "going on-site" for specialists' treatment.

3. IDD Learners as Players: Lessons Learned from P3S

A number of P3S smart spaces have been designed and evaluated in cooperation with therapists from specialized centres in Italy and the Netherlands. This co-design and evaluation activity have involved 22 specialists (psychologists, motor/psycho-therapists, special educators and neurological doctors) and 25 IDD children (25) in 3 therapeutic centers in the Milan area. While the systematic analysis of the qualitative and quantitative data collected so far is still ongoing, we can anticipate here two key lessons learned on the role of smart spaces and smart objects in the "learner as player" equation for IDD children. These ideas are conceptualized in Figure 2.

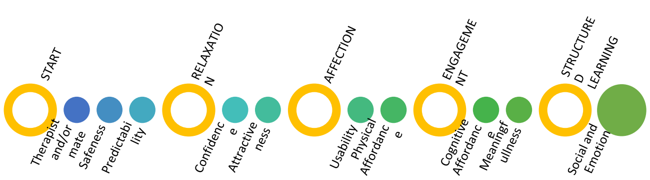

Figure 2: P3S Play&Learn "Model" for IDD children in Smart Spaces

Lesson 1.

The Play & Learn experience must be designed so that IDD children experience a progression of emotional/mental/behavioral states - *relaxation*, *affection*, and *engagement*. *The progressive achievement of these state during play is regarded as a form of learning for this target group and is a prerequisite to perform, and benefit from – any other, more goal/function oriented form of learning.*

Relaxation is an emotional state of low tension in which there is an absence of anger, anxiety, or fear: children must feel relaxed in the playground populated with smart objects and on-screen multimedia content; (s)he must trust them and must believe that these objects are "reliable", "good", "harmless", "inoffensive". *Affection* denotes a strong positive feeling of fondness and affective attachment towards an entity. Finally, children must feel *engaged* with these objects, i.e., they must reach an emotional state of involvement and willingness to act upon them, and maintain this attitude for a (relatively) prolonged way.

While engagement in relationship to learning is widely studied, current research has devoted less attention to relaxation and affection, which are fundamental in the learning processes of low-medium functioning IDD children. The intellectual disability induces a persistent state of insecurity, uncertainty, and inadequacy in these subjects. This in turn originates anxiety, fear for the new, and the related tendency to resistance to any change in routine. Relaxation is fundamental to help IDD children unlock their rigidity, and to predispose them to self-confidence and trust towards the learning objects they will interact with. Specific activities with smart objects and on-screen contents must be designed during which the child *learns to relax* in this new, unknown, and, from his (her) perspective, potentially worrying playground.

Only after this relaxation phase, the willingness to "connect" with these learning materials may occur and some form of interaction may start. Still, this attitude may remain episodic, and interaction may not continue unless a state of *affection* is reached. Children need to establish a strong affective bond (affection) with play materials (smart objects and on-screen digital materials) in order to use them for a longer time and in a functional, goal-oriented way. To reach the affection stage, children often play by exploring and discovering physical objects using all senses (touching, moving, eating, or smelling them), developing affection also from the pleasure resulting from these actions. Building affection is a form of *learning in the affective sphere*: children *learn to feel emotions*. In addition, affection is thought to be an emotional trigger that helps children to further release remaining tensions and to fully embrace the challenge of "getting involved", so moving to the engagement state.

It is generally acknowledged that *engagement* is facilitated by the fun component of a play activity and engagement in turn, as already mentioned, facilitates learning. With children without disability, engagement is mainly regarded as a learning facilitator. With IDD children, the engagement with learning material is not only a facilitator but also a form of learning per se, and a *precondition* for effectively participate in any more functional oriented learning tasks.

Lesson 2.

A consequence of Lesson 1 is the importance of distinguishing between "informal" and "structured" playful learning activities. "Informal" activities are designed to progressively achieve relaxation, affection, and engagement and should be proposed to IDD children *before* exposing them to more "structured" game-based learning activities. The latter involve game tasks designed for the improvement of specific skills in the cognitive, social, or motor sphere.

Lesson 1 has implications also on the design of the behavior and sensory affordances of smart objects and on-screen virtual worlds, which must take into account the requirement of promoting and maintaining relaxation, affection, and engagement. Important attributes for these play&learn materials are cleanness, minimalism, familiarity. Stimuli originated by smart objects or on-screen worlds must be clean, one-at-the time (avoiding overlapping stimuli), well distinguishable, strictly functional to a specific learning goal. Children are distracted from stimuli that are not strictly relevant for the current task and may lose engagement. Too many visual stimuli may induce anxiety as children may not be able to discriminate and interpret single elements within a group. In addition, to promote relaxation and affection, the shapes in the virtual world as well as the physical affordances of the smart objects should evoke characters and objects that children are familiar with, e.g., popular toys, or characters of well-known TV programs.

4. ACKNOWLEDGMENTS

We thank children and caregivers at the centers involved in our research: Centro Benedetta D'Intino (Milano), L'Abilita' (Milano), Sacra Famiglia (Cesano Boscone). This work is partially supported by POLISOCIAL grant "KROG" by Politecnico di Milano 2013-15 and by EIT Digital Project P3S – Activity Num. 15257 - 2015

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