Perform the Magic! Usability testing for Magika, a Multisensory Environment fostering children's well being

Giulia Cosentino, Mattia Gianotti, Mirko Gelsomini,
Franca Garzotto and Venanzio Arquilla

August 7, 2019

Perform the Magic! Usability testing for Magika, a Multisensory Environment fostering children's well being

Giulia Cosentino [a], Mattia Gianotti [b], Mirko Gelsomini [c], Franca Garzotto [d], Venanzio Arquilla [e]

[a] *GIULIA COSENTINO, Master Graduate; Dipartimento di Design del Politecnico di Milano (Italia).*
E-mail: giulia.cosentino@mail.polimi.it

[b] *MATTIA GIANOTTI, PhD Student; Dipartimento di Elettronica, Informazione e Bioingegneria del Politecnico di Milano (Italia).*
E-mail: mattia.gianotti@polimi.it

[c] *MIRKO GELSOMINI, PhD; Dipartimento di Elettronica, Informazione e Bioingegneria del Politecnico di Milano (Italia).*
E-mail: mirko.gelsomini@polimi.it

[d] *FRANCA GARZOTTO, Associate Professor; Dipartimento di Elettronica, Informazione e Bioingegneria del Politecnico di Milano (Italia).*
E-mail: franca.garzotto@polimi.it

[e] *VENANZIO ARQUILLA, Associate Professor; Dipartimento di Design del Politecnico di Milano (Italia).*
E-mail: venanzio.arquilla@polimi.it

SECTION

- ☐ Visual, Haptic and Urban Design *(Color, Light, Architecture, Landscape, Design for the common good)*
- ☐ Technology of Innovative Materials *(Surface design, Multisensory experience, Environment and society)*
- ☐ New Frontiers *(Product design, Human society 2.0, Open Innovation)*
- ☒ Communication Experiences *(User experience, Virtual learning environment, Identity and otherness)*
- ☐ Design for Social Innovation *(Political design, Co-design, Service design, Culture 3.0)*
- ☐ Health Science *(Well-being, Design for all, Advance simulation)*

ABSTRACT

This paper describes the result of an Usability Test over teachers' control interface in Magika, the powering engine of the Magic Room, a low-cost MultiSensory Environment (MSE) that enables new forms of playful learning for children, especially those with special needs. Magika offers a set of activities integrated in a synesthetic way; it incorporates digital worlds projected on the wall and on the floor with a large number of connected objects, such as toys and materials, that allow children to experience tactile, auditory, visual, and olfactory stimuli. The MSE has been installed in two elementary schools, therefore it is an essential requirement that the system can be controlled completely autonomously by caregivers. A preliminary research, based on teacher's needs, enlightened some basic requirements and allowed us to design a System Control Interface that enabled them to manage the experience within the MSE. The goals of testing the interface usability include: define a baseline of user performance, establish and validate user performance measures, and identify potential design concerns to be addressed in order to improve the efficiency, productivity, and end-user satisfaction.

In this work, we explain in detail the administration of the experimental protocol to ten teachers, tested for half an hour each, of two main scenarios: the Create modality, where users explored how to configure activities and the Play modality, where they had to manage the room.

Thanks to a background agent script that tracked number, position and time of each tap and results collected from SUS (System Usability Scale) questionnaire, we were able to obtain both quantitative and qualitative data useful to possibly improve our work and precisely evaluate the control Interface usability. Results appear to be consistent with the Usability of the control interface, as long as, no result was inferior of a score of 68 at SUS.

KEYWORDS

Multisensory Environments, Children, Usability Testing, Inclusion, Special Education Needs

Introduction

Advances in Cyber-Physical Systems and Internet of Things (IoT) in the last years and the increase of popularity of smart environments pave the route for the development of novel smart Multisensory Environments (MSEs) where the various sensory affordances are digitally connected, controllable, and interactive. MSEs, especially, have a relevance in the care of children with NeuroDevelopmental Disorders (NDD) [10].

Unfortunately those children present a set of deficits, from motor to cognitive and social capabilities, which affect their daily life. While in therapeutic centres those children are protected and cared with appropriate instruments, at school this may be impossible. In such environment social inclusion and integration between NDD children, their peers and adults is often complex and requires a huge effort by all actors. At school there is also the presence of other types of children with Special Education Needs, which require other form of attention and care.

This paper briefly describes the Magic Room, a novel digitally enriched smart interactive MSE. It has been designed by a multidisciplinary team to support caregivers in schools or therapeutic centres in the care of children with special needs and to help those children in their process of inclusion in the social environment. Two Magic Rooms have been installed inside two elementary schools, where children and caregivers may live multisensory meaningful experiences devoted to the socialization, appropriation of content or acquisition of authonomies for all children . In our discussion, we focus our attention on the design of the control interface, which allow caregivers to control and customize the experience for each child. This control interface has been co-designed in cooperation with 20 teachers and 10 psychologists of the two schools. Objective of the study was to determine the quality of the experience for the caregivers in terms of usability and perceived complexity of the usage of the system. On this tool, which we consider the key factor for the success of the Magic Room, we have conducted a usability study over 10 teachers: we used the SUS (System Usability Scale) questionnaires [3] and data extracted by a background agent script during the teachers tests to determine the usability of our system and determine the defects to correct in our work, obtaining a score of 68 at SUS. This paper describe the study definition and summarize the results of such study.

Related Work

Neurodevelopmental Disorder (NDD) is a term used to denote a set of pathologies arising in children during their development phase which limits their neurological, social and possibly also motor capabilities [10]. Multisensory approach's rationale is grounded on the theories of embodied cognition [11] and sensory integration [9]. The first emphasize the role of embodiment process in the development of some key cognitive skills such as mental imagery, working and implicit memory, reasoning and problem solving [11]. The latter posit that during the learning process the ability to integrate, and process multiple sensory information is mandatory [6, 7, 10]. When those processes present deficits, the resulting representation of the reality present abnormalities which affect the possibility of understanding the world. Thus, specific interventions for such people often aim at stimulating basic perceptual mechanisms and promoting perceptual learning [11]. Based on those theories it is possible to use a Multi-Sensory Environment (oftentimes referred to as Snoezelen [7]) - a room equipped with physical items and devices that provide gentle multisensory stimulations through sounds, lights, projections, soft fabrics and materials. Prior HCI research indicates that multisensory interaction in MSE where digital and physical world melt and combines provide support provides support for our target users. Physical interaction with devices such as described by Escobedo et al. [4], Beccaluva et al. [1, 2] can help children with sensory processing disorders to empower self-reflection, self-directed activity, and language. Among multisensory installations SensoryPaint [9] allows people affected by neurodevelopmental disorders interact with physical objects, movements and mid-air gestures, alone or in couples, in order to paint on a large projected screen receiving visual-aural stimuli as feedback for their actions. The reported study with target user showed an increase in the social capabilities of children when playing in cooperative mode and balance the children's attention between their own body and the stimulation provided by the environment. Another room-size multisensory installation, MEDIATE [8] let low-functioning non-verbal autistic children explore the environment in an unstructured and uninstructed way, providing visual, sounds and tactile feedbacks in response to gesture, footsteps and manipulation of affordances in the room stimulating creativity, exploration curiosity, sense of agency and self-expressions capabilities.

None of the cited examples of multisensory installation, however, present a control interface for the caregivers, leaving the educator in a pure observer role or acting on physical switches to change the state of the environment. The cited example, also, do not present clear education role for which the caregiver is required to determine a flow: the children explore freely the installation, without any specific education goal in mind. Finally those MSE have been designed for single user or at most very small groups of NDD children. The absence of an easy to use and ecologic control interface is one of the most cited causes of unuse of the MSE, leaving an environment designed for social usage in need of high skilled technicians. A similar option is not a feasible solution for MSE installed in schools or therapeutic centres. Thus there is the importance to design the control interface and co-design it with the final users.

What is the Magic Room?

We developed an innovative unconventional IoT enabled Multisensory Environment, evolution of a previous work called P3S [5]. The Magic Room is a room-size interactive MSE that enables new forms of playful interventions for children. This installation has been designed to let children with NDD, and more in general children with Special Education Needs in the school environment experience playful and learning activities improving their quality of life and inclusion in the society through playful learning experiences. The Magic Room has been designed to transform almost any room in a digitally semi-autonomous and affordable MSE, if compared to commercially available solutions. Magic Room is easily extensible in quantity and category of smart appliances available in the environment, available stimuli which can be detected or provided by the system and experiences available to the children and caregiver in terms of content or mechanics of interaction.

Currently, each installation of the the Magic Room is equipped with two projectors, one on the front wall and one on the floor, a 5.1 audio system, smart lighting (both portable and fixed on the ceiling), smart toys such as a smart stuff dolphin, a magic ball and a smart cash register, smart materials, olfactory machines and a bubble machine. The system perceives the children movements through a Kinect device and the interaction of the children with the smart objects, while the digital content is modified according to the children's behaviour and actions according to the flow of the current experience.

- ***Codesign***

In close cooperation with 20 teachers from two primary schools in *[omitted]*, where the first rooms have been installed, and 10 psychologists from two local therapeutic centres, we defined the room experience. The process of codesign aimed at increasing customer satisfaction and loyalty by improving usability and ease of use provided in the interaction between the caregivers and the system. Two workshops were held with teachers. The aim was to share knowledge on the educational needs of children with disabilities, the problems related to educational interventions for these subjects, in the school and extra-scholastic environment, and the identification of specific requirements to be addressed in the project. In the the first workshop we wanted to understand their technology knowledge level and how they imagined experiences in the room and we collected some information such as:

- The experiences should be carried out mainly in a group of 4-5 children, in some cases there will be single subjects;
- The time of the experiences should be 1 hour total, which includes movements from classroom to the room, the actual playing time will be 30 minutes;
- The devices to set the room experiences are PC and tablet;

After having discussed the previous points with them, another purpose of the workshop was to understand what is the ordinary process of children with disabilities integration in the school. In order to do that we use the User Journey Map tool[12] that allowed us to visualize at a glance a series of processes that would otherwise have to be analyzed in their single parts. We outlined with them the main phases starting from the first entry to school, then entering into the specific expectation regarding the room. During the second workshop we did a demo to make them understand the possible sensory stimuli.

Thanks to the codesign we outline users needs and weakness, given the variety of alternatives, we developed a solution that allows teachers and therapists to use the room in an intuitive way through a simple and usable interface.

- ***Magika: the Magic Room enabling software***

Magika is the software enabling platform powering the Magic Room. It is composed of a multilayered multimodal architecture of software packages. Such platform is able to make all the affordances of each specific installation of the Magic Room connect, coordinate and to tailor the setting to the specific needs of each user or group of users. The system provides a set of customizable game experiences each one devoted to a subset of specific purposes among which the caregiver can choose and personalize. The system is mainly autonomous during its execution, letting the caregiver spend quality time with the pupils and not worrying about the system management: the educator is in charge only on deciding which game to play, to tailor it according to the situation and children and then start it. However, we decided to let the caregiver the possibility to modify the flow of the activity and to manage the turn taking. To perform all such tasks the caregivers use a web interfaces, called Magika Control Interface (MCI), which is divided into three key moments: CREATE, PLAY and LIVE (Figure 2). In the CREATE educators can customize the games' parameters and save them for future reuse and or pack a set of those in an experience in advance. In the PLAY, available only inside the Magic Room, they can select which activities or experiences to do in the session and eventually which player may participate. Additionally, before playing, the educator can modify the activity's parameters to better tailor them on the children's' needs. In the LIVE they can control the flow of the game during execution. In order to understand the interface accessibility we tested it with the final users.

Fig.1 - The Magic Room affordances powered and coordinated by Magika.

Fig.2 - The three moment of Magika Control Interface: A) PLAY,B) LIVE, C) CREATE.

Usability test

- ***Setting***

It was important to test all the three key moments of the user flow: the activity configuration and the experiences creation (CREATE); the user orientation during the session as the selection of the activity or experiences to play, players addition and confirmation, activities control (PLAY); their activities control. (LIVE). (Figure 2)
Participants took part in the usability test at the primary school, a tablet with the web interface and supporting software was used in the multisensory room and a video camera was set. The test provided 30 printed task to complete and it last 30 minutes.
The roles involved in a usability test were as follows:

- Trainer: provide training overview prior to usability testing

- Facilitator: provide training overview prior to usability testing; defines usability and purpose of usability testing to participants; assists in conduct of participant and observer debriefing sessions; responds to participant's requests for assistance.
- Data Logger: data gathering control
- Test Observers: silent observer; assists the data logger in identifying problems, concerns, coding bugs, and procedural errors, serve as note takers.

- ***Goals***

The goals of the usability test were to establish a baseline of user performance, and to identify potential design concerns to be addressed in order to improve the efficiency, productivity, and end-user satisfaction.
We measured quantitatively how much time they will take in order to conclude the tasks and qualitatively we gave them a questionnaire in order to understand their perceived difficulty during the test.

- ***Participants***

Ten teachers were selected from who will use the room trying to create a heterogeneous group, priority has been given to support teachers. The participants' responsibilities were to complete a set of representative task scenarios presented to them in as efficiently as possible, and to provide feedback regarding the usability of the user interface.
Participants signed an informed consent that acknowledges: the participation is voluntary, that participation can cease at any time, and that the session will be videotaped but their privacy of identification will be safeguarded. Participants completed a pretest demographic and background information questionnaire.

- ***Procedure***

The participant read the task description e.g ("visualize the activities to play in the room") from a printed copy and began the task using the interface. Time-on-task measurement began when the participant started the task. The facilitator instructed the participant to 'think aloud' so that a verbal record exists of their interaction with the web interface. He observed user behavior, user comments, and system actions in the data logging application.
After each task, the participant completed a post-task questionnaire where they had to say in their opinion how complex it was to perform the task from 0 to 5, this allow us to understand their perceived difficulty for each task.

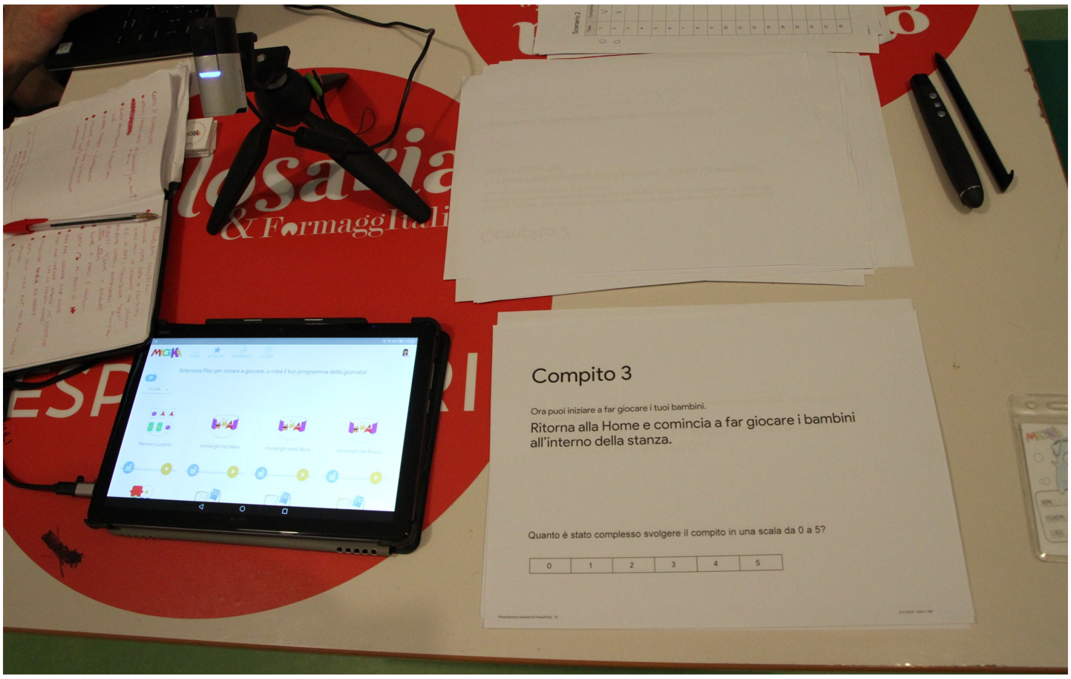

Fig. 3 - Test setting for the Usability Test.

- ***System Usability Scale***

In the final part of the test the participants are asked to compile SUS (System Usability Scale) questionnaire composed of 10 questions, concerning usability, which he must fill in independently.

The SUS questionnaire is useful to understand the results and analyze if the proposed concept has a good usability level [3]. Through a specific calculation the result is a number that it goes from 5 to 100.

- If the result is greater than 80.3 means that the participants loved the concept,
- If it is greater than 68 means that the concept has been well appreciated but could be improved
- if it is less than 51 means usability it is substantially low and should be improved seriously.

This was followed by some brief question on the general trend of testing and conclusions that measured their likeability and collected their helpful comments.

- ***Results***

Defining the Perceived Difficulty, as the level of frustration that the user perceived during each task, calculated by the post-tasks questionnaire, it was evident that the participants perceived a very low difficulty during the test. Indeed on a scale of 0 to 5,
only in two tasks out of 30 they perceived a difficulty greater than 2.
We can find the same results in the SUS questionnaire answers, for each participant no result is inferior of 60 and this confirms that the concept was appreciated by all of them. In six cases over 10 the result is even higher at 80.3, while only one case is lower than 68: this achievement makes us particularly proud of the work so far.

Users	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10	SUS Score	Average Score
U1	5	1	5	1	5	1	5	1	5	1	100	87.75
U2	4	1	5	4	4	1	4	1	4	1	82.5	
U3	4	1	5	3	4	1	4	1	3	1	82.5	
U4	5	1	5	1	4	1	5	1	5	1	97.5	
U5	3	1	2	2	3	2	3	1	3	2	62.5	
U6	5	1	4	5	5	1	3	1	4	1	77.5	
U7	4	1	5	2	5	1	5	1	5	1	95	
U8	5	1	5	1	5	1	4	1	4	1	95	
U9	5	1	5	5	5	1	4	1	5	1	87.5	
U10	5	1	5	2	5	1	5	1	5	1	97.5	

Fig.3 - SUS answers and scores

Conclusion and future work

Since the evaluation of the interface was carried out before the teachers training and therefore it was the first time in which they was asked to manage a multimodal system, we can say that the User Test has been complete in the best way and the data collected suggest both the multiple changes to do in order to improve the project.
We are planning to do an experimentation to test the usability of the interface while the children are playing and teacher has to manage both the system and children. And It is also planned to have a remote controller to help teachers in the management of the system.

References

[1] Beccaluva, E. A., Bonarini, A., Cerabolini, R., Clasadonte, F., Garzotto, F., Gelsomini, M., ... & Viola, L. (2017, August). Exploring engagement with robots among persons with neurodevelopmental disorders. In 2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) (pp. 903-909). IEEE.
[2] Beccaluva, E. A., Clasadonte, F., Garzotto, F., Gelsomini, M., Monaco, F., & Viola, L. A Robotic Companion for Dolphin Therapy among Persons with Cognitive Disability.
[3] Brooke, J. (1996). SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), 4-7.
[4] Escobedo, L., Ibarra, C., Hernandez, J., Alvelais, M., & Tentori, M. (2014). Smart objects to support the discrimination training of children with autism. Personal and ubiquitous computing, 18(6), 1485-1497.
[5] Garzotto, F., & Gelsomini, M. (2018). Magic Room: A Smart Space for Children with Neurodevelopmental Disorder. IEEE Pervasive Computing, 17(1), 38-48.
[6]Iarocci, G., & McDonald, J. (2006). Sensory integration and the perceptual experience of persons with autism. Journal of autism and developmental disorders, 36(1), 77-90.
[7] Lancioni, G. E., Cuvo, A. J., & O'reilly, M. F. (2002). Snoezelen: an overview of research with people with developmental disabilities and dementia. Disability and rehabilitation, 24(4), 175-184.
[8] Pares, N., Masri, P., Van Wolferen, G., & Creed, C. (2005). Achieving dialogue with children with severe autism in an adaptive multisensory interaction: the" MEDIATE" project. IEEE Transactions on Visualization and Computer Graphics, 11(6), 734-743.
[9] Ringland, K. E., Zalapa, R., Neal, M., Escobedo, L., Tentori, M., & Hayes, G. R. (2014, September). SensoryPaint: a multimodal sensory intervention for children with neurodevelopmental disorders. In Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing (pp. 873-884). ACM.
[10] Shams, L., & Seitz, A. R. (2008). Benefits of multisensory learning. Trends in cognitive sciences, 12(11), 411-417.
[11] Wilson, M. (2002). Six views of embodied cognition. Psychonomic bulletin & review, 9(4), 625-636.
[12] http://www.servicedesigntools.org/tools/8