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Enhancing Multi-Sensory and Handling-Based Psycho-Pedagogical Approaches through New Technologies

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Indice

Tangible User Interfaces for Multisensory Storytelling at School: A Study of Acceptability

Raffaele Di Fuccio, Sara Mastroberti***

Abstract

Interest in Tangible User Interfaces (TUIs) is quickly increasing, accompanied by interest in its impact in both formal and informal learning environments. Given its strong connection with the physical world, the TUIs are natural candidates to lead a revamping of the classical psycho-pedagogical practices. These traditional approaches could benefit from the expanded learning opportunities made possible through digital tool. In addition, the TUIs enable to explore a multisensorial approach, including smell that has enormous potential in learning.

This paper presents an application of a prototype that exploits the RFID technology, named Multi Activity Board (MAB), using a TUI approach. In particular, the study focuses on the acceptability of the mode of interaction. A storytelling approach was applied with three different interactions: traditional book, touchscreen with a tablet and multisensory approach with the MAB. Study participants comprise 59 children, all in the second grade of primary schools. The results show a high acceptability for the TUI tool (61%), greater than the tablet (25,4%) and book interaction (8,5%).

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1. Introduction

Education exploits the possibilities opened up by technologies. We use technology every day, from the simplest tools such as pens and paper, to the most innovative and complex technologies that benefits from the digital and the electronic components features. In education, in parallel with the technological aspects, methodological and psycho-pedagogical practices are of increased importance. In particular, some of these practices promote the exploitation of the sensorial channels in a multisensory way. The Montessori pedagogy represents an emblematic case (Montessori, 1967, 2013). The artefacts used in this pedagogical practice are wooden objects and toys, smelling jars, tactical tiles, and colored blocks that serve as materials for exploring the world and the surrounding environment for the child-learner, who can manipulate the objects and learn through experience (Dewey, 2004).

Nowadays technologies, including digital devices, surround us and are ubiquitous in all daily activities. Against this background, children are also embedded in a digital world and they represent the most active part of the population in managing the new tools and devices, and are consequently accepting this new scenario very quickly. These tools have extraordinary potential and appeal to young learners. However, a consequence of this appeal is the risk of negative behavior flowing from children spending too much time using digital devices and paying too much attention to them.

It is evident that digital technology has been rapidly embraced in education. This is related both to informal learning, with the presence of educational APPs with attractive and well-structured features; and for formal learning, where tablets and digital tools are slowly increasing their presence in daily routines. In this context, it appears paradigmatic the case of multimedia interactive whiteboard (Hillier, Beauchamp & Whyte, 2013, Zambotti, 2009) that is widely used in

European schools, creating new opportunities in didactic practices, but also presenting a range of challenges.

Proposing innovative educational tools, as attractive as commercial APPs, but, at the same time, at a high pedagogical level, is a current challenge; this APPs should also apply traditional psycho-pedagogical practices, so as to recover and exploit teachers' daily experience and skills. It appears even more challenging, in this context, to give new life to the multisensory approach in everyday school routine, even if it would be useful to promote inclusion, peer interaction and socialization between children. This goal can be easily achieved thanks to new technologies that bridge digital and tangible worlds, namely the tangible user interfaces. Using tangible user interfaces sets a strong connection between the learner and the learning environment, allowing interactions with objects mediated by all senses.

1. State of art

This paper exploits a methodological framework based on two main pillars: on one side the Learning by Doing approach (Dewey, 2004), that focuses on the unavoidable concept of the experience; on the other side the Embodied and Situated Cognition Theory (ESCT) that defines the correlation between our sensory-motor interactions within the environment and our neuro-cognitive structures organization (Shapiro, 2010).

On the technical side, there are tools able to join the educational aspects related to experience with the sensory-motor interaction within a learning environment (Giovanella, 2014). These tools, that permit the user to receive a stimulation that is both physical and digital, are the Tangible User Interfaces – TUIs (Ishii & Ulmer, 1997).

TUIs exploit the tangible, physical, materials in the environment and connect them with a digital component. With TUIs, the user interacts with a tool that is both physical and digital and manages real and physical materials in the environment, together with their digital parts, thus coordinating reality and virtuality.

These systems, strongly connecting physical and digital sides, create a kind of bridge linking these two worlds and allowing a natural interaction: natural because the user can easily understand it and interact with it in a natural way.

In the context of TUIs, the recognition of real object in a Virtual Reality environment is frequently considered a typical approach (Milgram, Takemura, Utsumi & Kishino, 1995; Carmigniani et al., 2011): this is the case of RFID technology Radio-Frequency IDentification (Want, 2006). With a thin adhesive film, placed under or inside the object, the RFID tag can be read by an antenna, thus allowing the recognition of the target material by a device. Putting the tag on the object is called tagging. The tag on the object has a unique ID that can be recognized by an active antenna and a RFID reader. This reader recognizes the ID and, consequently, identifies the tangible object.

The tagged object can be connected to a specific meaning, for example by the author of an educational exercise (Miglino et al., 2013): the object will embed the meaning as an exercise input. The tagged object is merely a physical object, which stimulates the user sensory channels; a red toy can be perceived with sight, a ringing bell can be perceived with hearing, a flower, or a smelling jar from Montessori multi-sensory materials, can be perceived with smell.

This latter sense, usually neglected in digital application, can also be important to enhance the learning experience and to improve memorization skills (Di Fuccio, Ponticorvo, Ferrara, Miglino, 2016; Ferrara, Ponticorvo, Di Ferdinando & Miglino, 2016; Ponticorvo, Di Fuccio, Di Ferdinando & Miglino, 2017). Indeed, olfaction has a fundamental role in learning, with relevant effects on brain activities, such as attention improvement in the role of evocative stimulus (Porcherot et al., 2010). In particular, some studies show that different odors stimulate specific zones directly in the orbito-frontal cortex, without previous sub-cortical elaboration (Savic & Berglund, 2000; Royet et al., 1999, Zald & Pardo, 1997; Zatorre, Jones-Gotman, Evans & Meyer, 1992).

Moreover, olfaction is important thanks to the strong connection between odors and the emotional sphere (Herz, 1998; Vernet-Maury, Alaoui-Ismaili, Dittmar, Delhomme, & Chanel, 1999). It is also well known that odors are relevant in memorization (Ehrlichman & Bastone, 1992) and may serve as a trigger for activating autobiographical memory contents (Chu & Downes, 2002). The connection between odors and memory is widely used in industrial fields too, for example, marketing exploits odors in product promotion (Krishna, 2012).

A very recent study has investigated the effects of olfactory stimulation on reading and learning (Bordegoni, Carulli, & Ruscio, 2017); it proposes an olfactory simulation in parallel with a reading text. Results indicate that introducing odors decreases the reading effort, at the same time improving satisfaction in the reading experience.

2. The MultiActivity Board (MAB): A TUIs application in TEL

The Multi Activity Book (MAB) is TUI application for learning purposes, in the field of the Technology Enhanced Learning. The MAB learning ecosystem consists of five elements: i) the educational application, ii) a smart device, iii) an output device, iv) a detect device, v) the tangible materials.

The educational application is the core of the system and it represents the main element for the education purpose. The smart device and the output device (screen or at least a speaker) are the digital components and they follow the logic and the visualization of the educational application.

2.1 The MultiActivity Board (MAB): Software branch

The software branch is represented by the educational APPs, for example the Multisensory Storytelling, where multisensory story is proposed to children, putting them in narration by using all the senses in order to learn some contents.

The software that allows the scenarios development is STELT Smart Technologies to Enhance Learning and Teaching (Miglino et al., 2013). STELT is a software that allows the creation of scenarios and applications using the TUIs thanks to an authoring system suitable for users with low programming skills too. STELT joins: i) communication protocols of the hardware (RFID readers), ii) logic of the scenarios, iii) learning analytics about the learners, and iv) adaptive tutors modules.

STELT allows the connection meaning-object, assigned during the tagging task: each object is equipped with a RFID passive antenna pasted on it. Pasting thin RFID tags inside (or behind) any object, it is possible to empower them in the form of a Smart Objects (Kortuem, Kawsar, Sundramoorthy & Fitton, 2010). The Smart Objects are recognizable by the MAB allowing the creation of games, learning exercises and scenarios. If an object is equipped with this antenna, the user could link the object in the storyboard using STELT, assigning to it a meaning: in this way the material becomes a Smart Object. With the MAB the learner has to interact with the exercise by using the tangible objects (the TUIs) and when he/she puts the object on the active board, the system gives an appropriate feedback. In the Multisensory storytelling, the smelling jars that contain a specific odor are logically related to the original object (i.e. the smell of rose with the “roses”, the smell of burnt wood with the “fire”, etc.). With MAB, the Smart Objects are designed to foster multisensory learning, using little jars that contains specific smells or tastes with RFID tags (Di Fuccio et al., 2016).

2.2 The MultiActivity Board (MAB): Hardware branch

The MAB (see Figure 1) is a wooden box, but it hides the electronic modules for the recognition of the smart object placed on it. The MAB can work both by USB cable andWI-FI. The screen (in the MAB used in this experiment is a commercial tablet connected with the active table) produces the feedback to the user by aural and/or vision channel (i.e. with a video, with a voice of the artificial tutor or with a text, etc.).

Figure 1. The MultiActivity Board, MAB

The system architecture includes: i) RFID antenna ANT_HF_310 X 180 (Antenna HF 310mm x 180mm), ii) RFID reader BlueRFID HF[1], iii) Main controller (with RX/TX module USB/Wi-Fi) with a Particle Photon (a tiny, reprogrammable Wi-Fi development kit for prototyping)[2], a STM32F205 120Mhz ARM Cortex M3 and Cypress BCM43362 Wi-Fi chip (Single band 2.4GHz IEEE 802.11b/g/n), iv) battery module equipped with MCP73831 for LiPo charging and a MAX1704X for fuel gauging[3] and a LiPo Battery 3000mAh (Di Fuccio et al., 2017).

3. Materials and methods

The experiment involved 59 children, 36 males and 23 females, attending the second grade in a primary school located in Rome (Ita-

[1] Sold by Tertium Technology (OEM Electonic Card able to manage reading and writing of HF RFID tags) (http://www.tertiumtechnology. com/it/bluerfid_hf.php)

[2] https://www.particle.io/products/hardware/photon-wifi-dev-kit

[3] https://www.sparkfun.com/products/13626

ly), named "Piaget-Majorana". Children were between six and seven years old and belonged to two different classes. Two children had special educational needs (mild cognitive impairment). No information about the socio-economic background or technology skills was collected before the trial. In the participating classes, normal routines applied traditional pedagogical practices with curricular books. In these classes, teachers did not perform any activity using tablets before trials.

The study investigated the acceptability of a Tangible User Interface device, namely the MultiActivity Board (MAB), which is an active table, embedding an antenna and RFID reader that recognizes RFID tags and, if tagged, tangible objects (Di Fuccio, Siano & De Marco, 2017). A complete description of the MAB device is given in the previous paragraph.

The aim of the study was to compare the acceptability of TUI (multisensory interaction) in comparison with the tablet (touchscreen interaction) and the traditional books for a storytelling scenario during normal learning routines in classroom.

The participants played three different and parallel stories, following the same pattern (multisensory with tangible objects, touchscreen with tablet and book interaction).

The interaction took place as described below:

- In case of *tablet use*, the user can interact with the touch-screen selecting the correct answer in order to proceed with storytelling. For example, if the character buys a roses' bundle, the children has to select the picture of the rose;
- In case of *book*, the user plays a game-book. Choosing an image that is functional to proceed the story (i.e. the roses), the user finds a number. if it is the correct answer, this number represents a page where he/she finds the next frame of the story;
- In case of *TUI application*, children have to interact with the tangible objects, i.e. the real doll of the character, the dress, the smells and the tastes related to storytelling, contained in smelling jars. For example, if Mickey Mouse is offering roses to Minnie, the user has to find the smell of rose between the smelling jars in order to proceed with the next frame/step.

Thus, the participant had some mandatory tasks for interacting with the story: i) one choice for a dress for the main character to wear (Snow White with a yellow, red or blue skirt, Mickey Mouse and Donald Duck with yellow, red or blue shoes); ii) four choices of objects (depicted in the case of the book and touch-screen interaction and inside smelling jars for the multisensory board) related to some specific points of the story, to be selected between 6 choices (apple, mint, fire, soap, rose, see) and finally; iii) one choice between two flavors or two image (strawberry, cherry). The game is named Multisensory Storytelling (Di Fuccio et al., 2016).

The children played with the different tools in groups (19 groups of three children, one group composed by two users). Each group played with all the three stories, each story had only one mode (TUI, book or tablet). The children were assigned to group and were associated to stories and interaction mode randomly. The order for different interaction modality (tablet, TUI, book) was randomly selected too.

The distribution of these sub-groups is shown in Table 1.

Table 1. Distribution of the story per way of interaction

	TUIs	Digital	Book
Mickey Mouse	19	20	20
Snow White	20	20	19
Donald Duck	20	19	20

The groups played with the three modes of interaction with a tutor. The tutor was a researcher that introduced the activities and had the role to support the children during storytelling. The tutor intervened only when children explicitly required direct intervention or when some relevant problems occurred (i.e. crush of the software, request of further explanations, etc.). Using this approach, the research was able to observe and record the behavior during the interaction, collecting qualitative data with an observational study.

When the group of children finished the three trials, the researcher called separately each child, avoiding consensual answers, and he/she asked the following question “Which tool do you prefer, and which one would you use for a new story?". The child replied having all the material in front of him/her during the question.

4. Results

The results are reported in Table 2 and Table 3, synthesizing the distribution of users' preferences about storytelling per mode of interaction; whereas Figure 2 shows the distribution of user preferences of the storytelling per mode of interaction. These results indicate that the Tangible User Interface and multisensorial materials are more accepted than the tablet and the book. 36 children, 61% of the whole sample, preferred the Tangible User interface application. The second preferred interaction mode is the tablet with 15 preferences, 25.4% of the children. Lastly, the book experience obtained five preferences with the 8.5% of the children. Finally, three children did not express any preference.

Table 2. Distribution of user preferences of the storytelling per mode of interaction

	Total	M	F
TUIs	36	23	13
Tablet	15	9	6
Book	5	3	2
No preference	3	1	2
Total	**59**	**36**	**23**

Table 3. Distribution of user preferences of the storytelling per mode of interaction (percentage)

	Total	M	F
TUIs	61,0%	63,9%	56,5%
Tablet	25,4%	25,0%	26,1%
Book	8,5%	8,3%	8,7%
No preference	5,1%	2,8%	8,7%
Total	**100,0%**	**100,0%**	**100,0%**

The qualitative observations reported by the researchers denoted a different children approach to the different modalities. The use of the MultiActivity Board and the multisensorial materials provoked some initial hesitations. In the progress of the activity, the participants using the tangible user interface collaborated actively in order to perform the task (i.e. find the right smell or wear the character with the dress). The interaction time was longer in the case of tablet, but it could be compared with the book experience.

In the case of the tablet, the interaction was very fast. Competitive behavior emerged and in most cases, the group preferred to give a quick reply than listening the story.

The children accepted and understood the interaction quickly. However, in most cases, the fear of a traditional reading assessment decreased the amusement of the experience. The book experience allowed the emerging of collaborative practices, i.e. the autonomous division of the reading task.

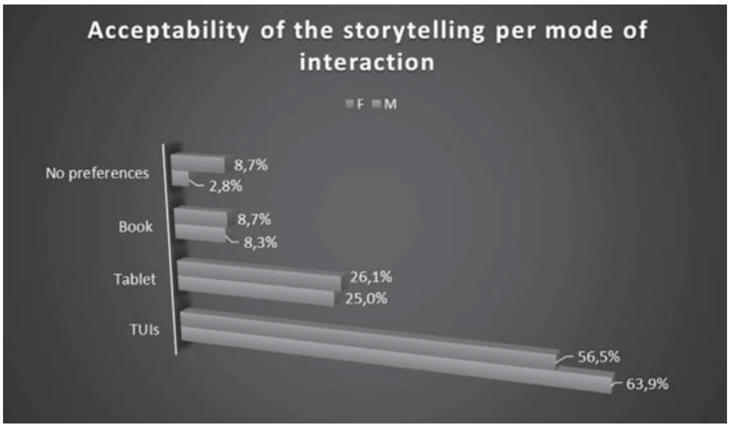

Figure 2. Percentage of the acceptability for the storytelling by the participants

Conclusions

This paper presents the comparison in the acceptability between Tangible User Interface, tablet and book in storytelling, performed in a classroom context. The main result that emerges brings a picture where the manipulation and the multisensorial approach joined with the digital devices has a greater acceptability than the other tools. The preference for the TUI tools, in comparison with the books, can be easily predicted, as it is traditionally used in classrooms whereas the preference of the TUIs devices in comparison with the tablet interaction appears surprising. Tablets are not wide-spread in daily educational routines in Italy and not at all for the participants involved, for this reason it should be attractive for children when these are brought in a formal context. Nevertheless, the simple and physical objects enrolled in the MultiActivity Boards (smelling jars, physical toys, little tissues, etc.) seems highly accepted by the children, more than the tablets. This result can open new trajectories, suggesting new learning exercises based on the Tangible User Interface approach.

The results of this study bring up new questions, highlight new dimensions to be assessed, such as assessing previous tools use, basic digital skills, socio-economic background etc. Moreover, it would be interesting to consider a wider sample and assess the effects with a follow up to verify the time effect. This study is a first to analyze the impact of these tools on learning performance and cognitive skills on the long term.

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