A New Graphic User Interface Design for 3D Modeling Software for Children

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Abstract Digital technologies have become a central part of the everyday experience the younger generation children and young people, born and raised in the ITC era, are known as digital natives. At school, this generation prefers active learning instead of being passive recipients of knowledge. This research proposes a new graphic user interface concept for a 3D modeling software program, designed for preschool and early primary school children. The interface of SugarCad Kids was improved to be more understandable, friendly, intuitive and enjoyable to use, in keeping with the principles of human-centered design.

Keywords Children · Preschool design · 3D software · UX/UI · GUI

1 Context

1.1 Digital Natives and ITC

From the early 1990s, new definitions began to appear defining the generation after Generation X (born between 1961 and 1981 in the era of the video game console and

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the personal computer). This new generation of people was dubbed millennials [1], the net generation, Generation Y, digital natives, and digital immigrants [2, 3].

These two generation of people have in common a world full of technology (ITC) and real-time information, which are also both useful factors for the school system, where learning should be more active than passive. According to cyberpsychology, new technologies (especially digital technologies) affect cognitive processing in digital natives, particularly their intuition, and the way they organize and implement their actions [4].

1.2 School Education and Learning for Digital Natives

According to Papert, knowledge construction is much more significant if it takes place in a context where the learner is engaged in producing something concrete and shareable. Errors are not negative, they are simply part of the learning process.

Making a mistake means exploring, learning from one's mistakes and looking for alternative solutions to the problem. The teacher's role is to guide children towards understanding their mistakes (debugging).

This form of mental construction and *concrete thinking* [5] can be summarized in this way: not learning to make, but making to learn [6].

Constructionism assigns a particularly important role to real constructions, as they support constructions in the mind. According to these theories, school should become a place where construction takes place, rather than being only a place for learning passively. Furthermore, it should feature dedicated learning environments with technology, where children are the main users (student-centered) and practical activities are the source of learning.

In February 2018, the Italian Ministry of Education, University and Research published new national guidelines highlighting the importance of improving scientific, mathematic and computational learning in three- to seven-year-olds. This is necessary to help them developing rational, logical, and critical thinking skills with which to solve problems.

The National Digital School Plan (Piano Nazionale Scuola Digitale—PNSD) calls for the production of creative ateliers in primary schools (Law no. 107, 13 July 2015 known as the “Good School” law). These are physical workshop spaces where maker learning can take place.

1.3 A New Teaching Methodology: Maker Pedagogy

The Maker Movement is a new frontier in artisanship; called 2.0, it combines the spirit of traditional crafts with new technologies.

In pedagogical terms, this culture has its roots in the principles of pedagogical activism and new schools, and also the Montessori and Munari methods.

Maker Movement pedagogy has combined the spirit of crafts with experimental play; it connects digital objects to material ones, through specific solutions that generate design models that can be produced using different fabrication technologies, including 3D printing.

In *maker pedagogy*, children are at the center of learning and their interests guide doing and learning activities through play, fabrication, designing and exploring (learning by making). According to Piaget [7], until the age of six, children learn mainly by working. This is why it is fundamental for them to work with all five of their senses in the first years of life.

An international study [8] shows that children three- to four-year-old have the skills to distinguish between geometrical forms, and they can understand their more basic properties like sides and corners. Children's interest in geometry could be enhanced and their knowledge expanded through targeted programs and early experiences [9]. These exercises are easy to achieve using 3D printing, offering children the opportunity to see their product being made, and increasing their metacognitive competence.

2 The Aim of the Research

This research *refers to Maker@Scuola: "Nuove Tecnologie per la Didattica"* [10], a project running since 2014 and developed by INDIRE (a government agency for research in educational innovation). The aim of the research project is to experiment new forms of laboratory teaching that are enhanced by new technologies (such as the 3D printer and the hydroponic greenhouse) at all school levels beginning with preschool and primary school.

In3Dire—a system that gives schools the ability to design and print 3D artifacts, even without an Internet connection—and a 3D modeling software called *SugarCad*, which is integrated into the *in3Dire* System, are part of the *Maker@Scuola* project. *SugarCad* was developed with the technological setting in mind, to resolve issues found in school environments. It was also designed to be used by students (and teachers) at different school levels and offers multiple interfaces for different user levels of experience.

The aim of this research paper is to define a concept for a GUI (graphical user interface) for a new level in *SugarCad* called *SugarCad Kids*, dedicated to children, three- to seven-year-old. This new level will join the two already available (basic and advanced). The aim of *SugarCad Kids* is to adapt the *SugarCad* GUI so that it is as intelligible, intuitive and enjoyable as possible to use, thereby improving its educational purpose.

Another goal of this research is to propagate a new way of teaching young users based on *learning by doing* and *learning by making*. This method can bolster the natural development of their skills and attitudes, starting from pre-primary level.

3 Research Method

3.1 Child-Centered Design

A good *user experience* from a product, a system or a service comes when the design is functional, and is easy to understand and use.

The research considers the user-centered-design (UCD) approach as the main method for child-centered design (CCD) [11]. The work also concerns human-centered design (HCD), a problem-solving process that focuses on understanding children's needs and behaviors in relation to the context they live in and their psychological traits and features. The HCD approach considers the needs and behaviours of people during the *design thinking* process and later when testing and validating the results [12, 13].

Furthermore, the CCD that goes into a product, a service or a GUI communicates clearly and interacts not only with children but also with teachers and parents. In fact, GUIs that have been designed taking into consideration the user experience (UX), not only meet the satisfaction of children and their friends, but are also more effective for learning. To summarize, a GUI should be playful, easy to use and suit the user's age [14].

A digital interaction for children should:

1. *Be efficient* (when the action time is too long, children think they are wasting time and stop playing);
2. *Be coherent* (when children recognize actions and interactions they feel at ease);
3. *Be responsive* (children need *feedback* for their actions so they can understand what is happening; they need confirmation and gratification);
4. *Enable them to test it and/or make errors* (this helps guide children around the GUI, because they sometimes lose focus and forget what they were doing, because they have found something interesting to click on);
5. *Be able to give visual clues* (preschoolers cannot read and even those who can, usually avoid doing so, particularly if they are using a digital device) [15].

3.2 Analysis

Users: children aged 3–7. It is a common mistake to think of children as a single category, and not relate their cognitive and mobility skills to their specific ages [16–21].

A four-year-old child's reading and mobility skills need different design solutions. Therefore, sub-categories of user/child should be taken into consideration.

Some researchers and professionals in the field of new digital technologies use a 3–6–9–12 age grouping model [22], which contains three age groups: 3–6, 6–9 and 9–12 years. Others suggest a 2–4–6–8–12 format with four different groups. This one is more appropriate, because it reduces the range within each group from three

to two years, [23] and defines the user more accurately. As the target for SugarCad is children in preschool and the first year of primary school, users have been analyzed according to the 2–4–6–8–12 model, mainly considering those aged three to seven.

2–4 years. This is an important age range because during this period children become autonomous (from babies to small children).

The GUI should have the following features:

1. A clear visual hierarchy (children usually focus on details, which is why it is necessary to create a clear visual difference between interactive and non-interactive elements);
2. Few bright colors (too many colors confuse them during activities);
3. Elements on the screen should correspond to a single behavior (2–4-year-olds can only link one function to an element or object they are interacting with);
4. The background should be clearly distinguishable from the foreground;
5. Images and icons with no text.

4–6 years. A GUI for this age group should be more than a modified version of the one for two- to four-year-olds based on their different skill levels. Their interaction with the interface should be stimulating and should take into consideration what they already know and their collective imagination. As they approach the age of six, students are able to solve relatively complex problems and make mental classifications quite efficiently. They are also quite loud and have become technologically adept.

4 The Project: “SugarCad Kids”

4.1 Wireframe and Logo

The practical activities on the SugarCad software were focused on the design concept for the new GUI. Since it had features that were closer to those needed for the target group, the existing platform’s basic level interface was used as a starting point for analyzing how to improve usability, interaction and UX in general.

This analysis identified the actions users would perform when working from this new level (SugarCad Kids). This led to a new task analysis, a new task flow and, subsequently, the layout of the prototype for the new GUI.

The wireframe design also took account of factors like content (text, images, icons, etc.), functionality (commands, buttons, sliders, feedback from commands, etc.) and navigation (the way the content and the various functions are located and used). The project proposes four wireframes for the *welcome page*, the *switch page*, the *freehand drawing page* and the *3D geometric shapes page*. The idea of giving SugarCad Kids its own identity led to the creation of a dedicated logo, which kept a sense of continuity with the other levels of the software. At the same time, it

had its own recognizable identity more suited to younger users and their collective imagination.

4.2 *Graphic User Interface for Children (3–7-Year-Old)*

Neutral colors were used for the background to create greater contrast and the features become more readable. It also helps the visual separation of different interactive elements.

The action icons were enlarged, using homogeneous colors, depending on their position on the screen. Where possible, these positions were kept the same on both main pages (*freehand drawing* and *3D geometric shapes*), to ensure continuity, avoid visual confusion and help users find their way around the GUI. In some cases it was seen that icons were difficult to interpret, even for children who can read, so a text reference was added in the web version of an easy-to-read, dyslexia-friendly font. The icons of the 3D geometric shapes were given anthropomorphic characterization, making them as close as possible to comic or cartoon characters that children are familiar with, and more playful. It may be possible to add a simple animation that can be activated when a finger hovers over or touches the character.

Message boxes have simpler, clearer, child-friendly graphics to ensure instant feedback and further improve UX.

5 Conclusion

This paper has considered children's abilities in relation to the maker learning approach. Unlike traditional learning, this method gives a child more scope to express his/her creativity actively. The distinctive aspect of this project is the attention given to the graphic design, with the purpose of making the interface more appealing and intuitive for children. It also underlines the significance of adapting the interface to suit different users (children).

The study of children's characteristics made it possible to define project rules that could be applied to the graphic user interface for younger users, to make it as child-friendly as possible. This method could be used to design other CDC GUIs for digital products, and not only in learning environments.

The following points summarize the proposed elements that can be used to design this kind of "kid-sized" interface.

1. *Functionality* in relation to children's abilities. All the interactive commands and feedback must be easy to understand and easy to use.
2. The *visual design* of the GUI. All icons and shapes must be fun-looking, inspired by children's collective imagination (e.g., cartoons). The meaning of

actions should be immediate to avoid confusion and distraction; they should be accompanied by animation and video, where possible.

3. *Cognitive aspects.* The cognitive skills of young users change rapidly.

The GUI's visual language should take account of children's imaginations; they need fun, playful elements to enable them to approach maker learning. This helps children's experiences become a new way of learning that is more active and less passive, and leads to better results. We hope designers can use this approach to GUI design for future CCD digital products for teaching and learning in line with *maker pedagogy*. Our aim for the next year is to finalize implementation of the interface and begin the first experiment with students at school. This will enable us to analyze the strengths and weaknesses of the interface and improve it.

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