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13TH INTERNATIONAL CONFERENCE ON EDUCATION AND NEW LEARNING TECHNOLOGIES

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CARDBOARDIFICATION: FROM PLAY TO KNOWLEDGE

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Abstract

The inexorable technological evolution, supported by the growing adoption of digital products, is progressively transforming the canonical physical objects into experiential objects while changing the way we interact and relate to the real world [1]. This change is generating new lifestyles, new opportunities, and new design challenges. Through increasingly smart and interconnected objects, it is possible to create shared activities and experiences that overcome the barrier of the "tangible", to land in increasingly immersive and attractive environments. Such interactions amplify the need to create meaningful content, extending our perception beyond purely physical reality.

Starting from a research on "Corrugated cardboard and Digital technologies" carried out at the School of Design of the Politecnico di Milano, in collaboration with a leading company in the packaging sector in Italy, we examined corrugated cardboard from different points of view.

From the analysis carried out, we were able to see how, still today, corrugated cardboard is perceived as a cheap material with little value. But the same material, when placed in a digital scenario, could acquire value by giving tangibility to immersive digital experiences.

From these considerations derives the neologism "cardboardification", a transformation that enhances corrugated cardboard to technologically advanced material, evolving from a container of physical elements to a container of digital content.

As technologies change, so do formats and quality of content, dematerialising and giving rise to new customisable experiences that are potentially useful in mitigating the differences between users. In a broad and changing framework, learning is also undergoing important changes, leaving great room for improvement, especially considering the generational and skills gap between immigrants and digital natives [2].

Digitisation allows for a vast amount of innovative content that can activate parallel learning processes, without replacing the canonical teaching activities proposed by educators. In this logic, ourproposal aims to outline elements that, through play and cardboardification, accompany the educational processes useful for the growth of the child, not only by making available digital content, but tangible augmented experiences that act as a bridge between the physical and the virtual [3].

Keywords: game based learning, augmented reality, edutainment, digital natives, cardboardification.

1 INTRODUCTION

"Design innovation generally does not conform to dominant aesthetic standards, but creates new canons and seeks to transmit them to society, which is constantly evolving" [4]. Progress can be equated to a continuous process of development, a loop, in which moments of innovation andrefinement alternate.

This process can generate multiple scenarios and opportunities for growth [5]. In this context, the figure of the designer assumes a relevant role, as it is stimulated to rethink tools, experiences, and habits of future users. This is possible thanks to the transversal and multidisciplinary skills that characterise it, combined with a human-centred approach and the propensity to manage complexity.

If on the design side, the progress-user relationship stimulates the rethinking of "contextual" and future-oriented products and services, on the business and working side, the same relationshiprequires a rethinking of its offer: no longer just a product but an experience.

The adoption of new technologies, both by the individual user and by companies, enables thegeneration of new products and services suitable for the fruition of enriched contents, creating new meanings and influencing changes in the context.

In this framework "design-driven innovation", defined by Verganti as an "innovation of meaning" absorbs the innovation "technology-push" [6] becoming itself a means that allows technology to redesign the competitive logic of the market and the mode of access/use by users.

This awareness has guided the path taken at the Politecnico di Milano, with the aim of designing a product/service/system solution that allows the enhancement of the company's assets, through the use of digital technologies with the aim of giving a new meaning to corrugated cardboard.

2 METHODOLOGY

The analysis carried out was addressed through three phases: research, scenario definition, and eventually the generation of a design proposal.

The research and business analysis phase was conducted using strategic design tools, in order to understand the configuration, organisation, and production processes. Starting from this analysis, the company's strengths were defined, among which the following stand out: know-how, customer service, and technological skills. At the same time, external research has been carried out, analysing the main direct and indirect competitors, dividing them into four groups with respect to: turnover, presence and distribution on the territory, and technological potential.

In the following phase, possible fields of intervention were researched, with respect to: innovation trends related to materials, inks and coatings, production technologies, and digital technologies. To these were added those related to trends in services, strategies, and marketing. From the research carried out, through a brainstorming session, it was possible to generate several macro-scenarios withrespect to the development of the reference market and the future society.

In the scenario definition phase, it emerged how cardboard can take on different meanings and acquire different values with respect to the characterisation of the scenario itself. It also emerged how, in a general sense, education and entertainment can offer design opportunities that are transversal, broad, and coherent with respect to material and digital technologies.

Once the application areas were identified, it was necessary to deepen them in order to better define the "age of the target" and the skills that the latter can learn and master.

3 RESULTS

With regard to what has been described, it is easy to understand how "design push" processes can give rise to new design paradigms, which can create an added value capable of identifying newmarket opportunities through the understanding of new user needs left more or less unexpressed.

To support the analysis carried out, some relevant and potentially implementable case studies were identified, which stood out for the particular attention paid to materials, technologies and user experience.

3.1 Case studies

The first case examined was Nintendo Labo [7]; a kit that amplifies the concept of gaming and goes beyond traditional video game logic. Nintendo Labo consists of 2 parts, one includes the software and one the hardware components. The provided add-ons consist of pre-cut sheets of cardboard and other materials that must be assembled in combination with the Nintendo Switch console and Joy-Con controllers to create a "Toy-Con" that can interact with the included software and vice versa. Nintendo designed Labo with the intention of conveying the principles of DIY, computer science, and basic coding, without neglecting the material and experimental side.

Smartipresence [8] follows a similar logic, being a kit to build cardboard robots with items easily available at home, which take advantage of AI and are controlled by apps, allowing the creation of mobile structures that act as a support for the smartphone during video calls, allowing people to havea physical entity even remotely.

Among DIY products, we also analysed the Animate case [9], a robot creation kit intended to make electronics fun and accessible to children. Animate is targeted toward users between the ages of 6 and 10, allowing them to create toys using cardboard, batteries, cables, buzzers, sensors, motors, and LED lights. The kit also includes a guide to help children with their projects, and all electroniccomponents are intentionally oversized and finished in playful shapes and colours to appeal tochildren. "The project introduces technology as a creative tool that allows children ages six to 10 to animate their own creation."

Particular cases were then analysed in which the application of new technologies enabled the creation of new and more immersive experiences, as in the case of Amazon AR [10]; an augmented reality experience launched in the Halloween period in which users are invited to draw in a special area on the package and watch their drawing come to life through augmented reality.

Another example is offered to us by Knäppa [11], a camera made of cardboard and electronic elements, used to invite IKEA design-week guests to visit and photograph new proposals.

Case studies identified as particularly interesting for children were those in which manual skills were amplified by multimedia content. Among the many we can mention:

Lego's Hidden Side [12], a set that combines typical Lego creative play with augmented reality (AR). This product aims not only at creating engagement for the individual user but also aims at forming playgroups in which the various players can cooperate or compete with each other using their imagination.

Pick&Play [13] by Grinrise, an interactive "puzzle" that empowers children to generate wacky, animated combinations via a kit. The augmented reality-based process gives children the ability to create their own stories using animated word cards via a mobile device and simple coding. The set includes 64 word cards that are made up of five categories: character (who), object (what), action (how), background (when and where), and sound.

RBA's My zoo animals [14] is a collection of "books" that allows children to play and discover information about their favorite animals through digitally augmented experiences. We can see that the last three case studies are specifically designed to offer preschoolers age-appropriate content with simple text, puzzles, and games to make learning fun.

3.2 Potential of augmented reality

Augmented Reality (AR) is an emerging form of experience in which the real world (RW) is enriched with virtual content related to specific places and/or activities [15]. Such content can be enjoyed by the user through the recognition of an image, or a tag, through the use of a smartphone PPC or a dedicated tool. The device is configured as a filter between the user and reality assuming the role of mediator between the virtual and the physical.

We can therefore imagine this technology as an opportunity to enrich the information of a real object with content, including multi-sensory, implementable, and upgradeable over time.

Today, AR is used in multiple sectors, from play to industry, thanks to its versatility and customisation related to the ability to generate both static and interactive content. As pointed out by Billinghurst (2002) [3], "unlike other computer technologies, AR interfaces offer a seamless interaction betweenthe real and the virtual, a metaphor for tangible interface and a means to transition between the two worlds."

From this, it can be deduced how this tool can represent a breakthrough in the field of childhood education, capable of transmitting knowledge and knowledge, through modalities of fruition that can keep up to date with the social changes.

3.3 Vision

The analysis of case studies and technologies, integrated with contextual and market surveys, was synthesised through strategic design tools. This allowed us to highlight cross-sector trends, such as entertainment, education, personalisation, and sustainability.

The results deriving from the generation of macro-scenarios have highlighted how the reference material can enhance the educational context, allowing a high level of personalisation, enabling the use of augmented experiences, characterised by both physical and digital elements.

All this has been synthesised and concretised in a univocal vision through the definition of "carboardification". This neologism wants to represent the change of meaning of cardboard material in the eyes of users, passing from packaging to a means of fruition of new experiences, both physical and virtual. The concept of cardboardification can be applied at various levels and contexts, both business to business and business to customer.

By transforming the meaning of the reference material, and the transformation processes connected to it, it was possible to give a new vision of the company's potential, strategic opportunities, and new business scenarios.

Thanks to digital printing and cardboardification, the cardboard acquires, in addition to the most classic characteristics of affordability, sustainability, and recyclability, characteristics of upgradeability, and customisation that make it a suitable material to become a "portal for multimedia content".

3.4 New learning paradigms for digital natives

The protagonists of this change are the digital natives, who, unlike their predecessors, are born into a completely digitised world, and interact with reality through different patterns and behaviours, immediately interfacing themselves with smartphones and digital media. These users, whose lives are closely related to the new technological opportunities, need to acquire more and more up-to-date knowledge in order to ensure an adaptation to the new standards.

As stated by Romina Nesti [16], a game-based learning approach provides various tools that can enhance the educational experience, such as the use of gamification, serious games, and virtual worlds. These present a high level of interactivity combined with the ability to engage and immerse children in the experience, transporting them to other worlds, experiencing new roles and characters. This type of approach allows the user to be involved and motivated, inviting them to learn actively, promoting critical thinking, storytelling, and problem-solving.

The traditional concept of learning is therefore undergoing significant changes, intertwining with practices typical of entertainment and gamification. Despite the fact that technological evolution is increasingly accessible and democratised, the world of private and non-private education, often struggles to keep up for several reasons including the ever-present economic problems and upgradability of educational practices. One of the critical factors for the success of play-based educational approaches, as Tamara R. Meredith [17], is " its acceptance as a legitimate educational practice by administrators, teachers, and parents," so that it is not seen as a purely play-based practice, but as an innovative educational approach that is just as valid as its traditional counterparts.

3.5 Design opportunities

The solutions based on the concept of cardboardification aim to accompany the user during the years of training, presenting a life cycle less impactful if compared to that of other materials, proving to be easily recyclable and replaceable with new content or updated forms.

By addressing the training needs of students, these solutions can allow them to develop manual skills through a "do it yourself" approach. In fact, the material is easily mouldable, through cuts and joints. Added to all this are the elements activated by technology, which through augmented reality allow children to access extensive information, interacting through gamification in order to arouse interest and improve the permanence of concepts in the memory.

The solutions below, reinterpret the concept of cardboardification through two points of view, which differ in the mode of transmission of information and the interaction on which they are based.

In the first case, an approach is proposed in which the user has at his disposal various elements, both physical and virtual, with which he interacts in a ludic yet educational way without modifying the contents but enriching his knowledge through them.

In the second case, the user, thanks to the physical elements that are provided, has the opportunity to interact not only physically, but also digitally, creating new content and developing skills such as creativity, storytelling, and problem-solving.

3.5.1 Enhanced content fruition

The first project proposal is in the field of education and training applied to the preschool level. "This first step of the educational pathway contributes to the education and affective, psychomotor, cognitive, moral, religious and social development of children, stimulates the potential for relationships, autonomy, creativity, learning, and aims to ensure an effective equality of educational opportunities. The kindergarten, with respect for the educational role of parents, contributes to the integral formation of children and, in its autonomy and unity didactic and pedagogical, achieves educational continuity with the elementary school" [18].

The concept was developed starting from a preliminary phase of analysis regarding the ministerial program [19] and the activities of integrative teaching, paying particular attention to the Steiner Method reported in "Education of the child and preparation of educators" [20] and Bruno Munari laboratories in "Tactile laboratories" [21].

The canonical ministerial topics combined with a more "free" education method generate teaching scenarios that facilitate the learning of skills through a more horizontal approach, in which the user acquires a set of concepts through active guided discovery and not passive teaching.

Once the formative analysis phase was completed, market research was conducted on toys and technologies for educational-didactic purposes. The research showed how the entities that contribute to children's education have a propensity to purchase canonical learning tools such as toy cubes, constructions, elements that depict animals, etc...

The macro-phase of analysis has contributed to the definition of the characteristics of the concept that take up basic three-dimensional geometric elements with colourful graphics, simple and intuitive through which to build and create "stories" further charged with meaning and value through the use of augmented reality.

The research phase ended in conjunction with the formal definition that synthesised all the values and data resulting from the phases under analysis into a product/service/system proposal.

Through this type of approach, the physical element in cardboard, which is the part of physical and playful interaction, is linked to digital content that can be activated through devices, via marks that are directly printed on the product.

The concept is presented as a kit composed of basic 3D elements made of corrugated cardboard, to accompany the user from 4 to 6 years old through the discovery and learning of numbers, alphabet, shapes, and animals. Each physical element "contains" a series of augmented contents, thus generating a guided fruition of multidisciplinary contents that enrich the canonical knowledge through two phases.

The first phase of user engagement through physical play and tactility and a second phase, the digital one, which provides additional content to complete the activity or trigger new cycles of digital learning, to this are added group activities that aim to enhance and stimulate sociability and cooperation between the various users.

With AR, classroom teaching changes profoundly in nature by becoming much more interactive, as it allows teachers to show virtual examples of concepts and add game elements to provide additional support. This will allow students to learn faster and memorise information.

3.5.2 Storytelling and augmented features

The second design solution saw the concept of storytelling as a starting point. Narrative-based processes enable users to make sense of unusual situations, facilitating understanding of cultural dynamics and the meanings that govern society [22]. This, when applied to children, allows them to let their imaginations run free, create and make sense of the situations around them. During childhood, children need to explore and learn about the world around them, participating actively to stimulate creativity and memory [23].

The narrative process, which leads to the creation of stories, allows the re-interpretation of situations and phenomena that characterise everyday life in order to gain an understanding of them [24]. One of the ways in which children can identify with these situations is through the act of play, a fundamental part of cognitive development. During playtime and entertainment, digital natives prefer apps and products that encourage exploratory and creative play, promoting critical thinking, storytelling and problem solving [25].

Technological change has led to an increase in the use of electronic devices, exposing children to more and more digital media [26].

In this way, digital natives often adopt a passive behaviour, becoming mere spectators, with consequent inhibition of imagination and creativity.

It is, therefore, necessary to facilitate the transition from digital natives to digitally aware natives, providing children with the tools to understand and manipulate the world, increasingly influenced by the digital sphere, through activities that present a playful and an educational part, also exploiting the possibilities arising from the "STEM world".

The design proposal is developed in the form of a system, providing digital natives with elements of entertainment and education, allowing them to develop creativity and storytelling skills. The interaction takes place through augmented reality and sensors, in order to develop in parallel narrative and STEM skills necessary for the proper development of the child.

The system takes the elements of the stories, defining a context, buildings, characters, and add-ons, which can be assembled and coloured by children. To these elements is added a robot, which incorporates sensors of various types and acts as a guide during play, providing feedback and directions. The experience is expanded through augmented reality, supported by apps, and allows the child to explore, play individually or in groups, and finally create their own stories, setting marks and sensors, and then share them with their friends.

The experience accompanies the child through the stages of their growth via different interactions, designed specifically to facilitate the achievement of the educational goals of each age group.

Children between the ages of 3 and 6 years old need to develop basic skills in order to become familiar with reality, all while using creativity as a means of discovering the world to develop memory and imagination. The activities dedicated to them include the development of creativity through customisation and drawing, then carrying out the activities of assembling the various elements with the help of an adult figure, and finally playing with the physical products created.

Children between the ages of 6 and 9 need to consolidate their knowledge and can use creativity as a means of understanding how reality works. In addition to the development of imagination through customisation and assembly, this type of user can begin to play not only through the physical part but also with the support of digital and augmented reality. This allows them to identify with the setting and characters, creating stories that can draw on events in their everyday lives.

Finally, children between the ages of 9 and 12 need to expand their knowledge, putting into practice advanced concepts, using creativity as a means of manipulating reality in order to interact and plan their own experiences. For them, in addition to the already mentioned experiences, it is also possibleto develop basic skills belonging to the STEM field, to program and control elements managed by sensors and marks in order to create their own stories and share them with others.

4 CONCLUSIONS

At present, the research carried out has generated a very broad and constantly evolving scenario where it is evident how the contamination between different fields of application generates new visions projected towards an increasingly smart future, making it possible to reimagine the perception of the material and extend it beyond the world of packaging.

The tools based on the concept of cardboadfication embrace not only the traditional skills necessary for the correct development of children but also basic digital skills, suitable for the new social context strongly influenced by technology.

While there are many design possibilities, they require common elements both physically and digitally, as well as a willingness on the part of educators to be open to new educational practices. The designer empowers these figures, who have been reluctant towards technology, allowing them to become participants in this change.

It is not only necessary to design the tangible solution, but it becomes essential to design the entire educational experience so that physical interactions and digital content can coexist, complementing each other. The lack of either of these two elements would result in the generation of sterile solutions from an educational point of view.

In conclusion, the concept of cardboardification enables the generation of new paradigms in the world of education, proposing an immersive learning experience, characterised by the use of augmented content. Through this process, the preparatory activity no longer takes place passively through books, but actively thanks to tools that support educators in achieving their educational objectives, improving the quality, and allowing them to be updated over time.

It would be interesting to examine in concrete terms the applications that the concept of cardboardification could have, through the active participation of transversal figures that enrich the design operation carried out by the designer.

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