DESIGN THINKING AS A TOOL TO THE TEACHING OF CHILDREN, AND TEACHERS IN THE 21st CENTURY: An Integrative Review

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Abstract

Children become more motivated to learn when what is presented to them reflects or simulates their own reality, providing a sense of authenticity to education. This article aims to analyse which studies have already been carried out in the scope of the use and teaching of Design Thinking for children in the school environment. In order to achieve this aim, a descriptive exploratory research was conducted, based on the integrative literature review, with the Scopus and Web of Science platforms as the basis. It was noticed that Design Thinking is a valuable tool for the empowerment of children and adolescents, as it stimulates empathy, communication, creativity, and the ability to analyse and solve problems. One point that should be drawn from the articles is that there is few formally structured materials on the use of Design Thinking as a pedagogical practice, which can hinder its more accelerated dissemination. Finally, although interventions are centred on children and adolescents, educators need to realize that they are the primary factor for transformation, through their involvement, dedication, and attitude. Therefore, they need to be qualified, aware of their role as facilitators, guiding in this collaborative journey of critical thinking, and problem-solving in an innovative and future-oriented way.

*Keywords***:** Children; Skills; Design Thinking; 21st century; Integrative Review

1. Introduction

In recent years, a global movement in the field of early childhood education has been happening, concerning the necessary skills children should develop to be successful, economically productive and actively engaged citizens for modern society, which is understood as highly volatile, uncertain, complex and ambiguous. In this perspective, according to the OECD (Organization for Economic Development Cooperation), and the understanding of (Anagün, (2018), Sylva *et al.* (2020), and Zulkarnaen *et al.* (2019) the main skills needed for the 21st century are as follows: critical thinking, problem-solving, creativity, communication, collaboration, innovation, teamwork, decision-making, leadership, knowledge application, self-direction, and learning to learn.

It should be emphasized that, although there is already some clarity about what skills are necessary for adaptation, and better fluidity in modern society, a concern also lies in how to facilitate the acquisition of these skills, which results in the review of educational environments, and pedagogical practices. Children are currently subjected to a large daily dose of information, transiting in a hypermedia world, and are protagonists of digital access. They can communicate with a simple click of a button, and no longer can be seen as empty "containers", willing to passively receive content, often sterile, and that does not integrate with their longings. From this perspective, Anagün (2018) brings us that the creation of an effective learning environment has become one of the challenges to help students get involved, interpret, and give meaning to their surroundings, co-assuming responsibility for their learning.

Thus, there is an appreciation of the constructivist method of education, in which knowledge is not something fixed, and stable, on the contrary, it is constructed step by step and often changed. Knowledge would not be either in the subject or in the object, but it would be the result of the interactions between them; this interaction means assimilating the object to its structures. Costa *et al.* (2018), brings the understanding of Jean Piaget, in which it is necessary to teach students to think, what is not possible to be done in an authoritarian environment, without freedom or autonomy. Therefore, it can be concluded that for learning, motivation and interest are essential.

According to Corrêa (2017), "the intervention of interest mobilizes the internal reserves of strength, in such a way that there is a feeling of ease, and a decrease in fatigue ", and, according to Allegretti (2003, apud SOUZA, 2012) "it is important to put the learner in the face of challenges, provocative situations that awaken in him the need to research to solve real, and significant problems, and, at the same time provide search, and discovery conditions, associating learning with problem-solving". In this sense, there is the importance – or even the necessity – of incorporating new strategies and pedagogical support tools, so that children are positioned to face real challenges, that are part of their daily lives, feeling motivated to critical thinking, collaboration, empathy, and problem-solving.

Such understandings align with the so-called STEM education being, conforms Pugliese (2017), an innovative, and integrative proposal in the teaching of science, technology, engineering and mathematics that breaks with the traditional, and passive model, which tries unidirectionally to pass information, and concepts to students without interaction with the object of the study, however, with no meaningful correlations with the real world. As Sen, Ay, and Kiray, 2018 STEM education aims at the development of critical sense, research, logical reasoning, and collaborative work, supporting the goal of training more qualified individuals for modern society.

Thus, in the perspective of making teaching more attractive, adhering to reality and more easily preparing students for the 21st century, the following research question comes up: can Design Thinking be used by children in the school environment, as support for critical thinking and problem-solving capacity? After having defined the research question, the topics follow the sequence of theoretical reference, methodology, results, discussions, so then conclusions can be taken from this study. It is notable that in this type of research, it is fundamental to have a broader view of the use of Design Thinking as an instrument in teaching.

2. Theoretical Framework

Thereafter, we present the theoretical foundations related to the topics addressed, "Design Thinking" and "STEM", intending to merely conceptualize them, as related in this research.

2.1 Design Thinking

Design Thinking can be understood as a methodology for innovation, and development of products and services, centred on the human being. The development and expansion of Design Thinking in the most diverse areas had as a fundamental part a company called IDEO, responsible for an extensive list of innovations (BLEICHER, 2015). Located in California, United States, the company serves customers of many sizes and segments, including Google, Mattel, Swarowski, IKEA, Lufthansa, HBO, NBC, Bayer, Ford and American Express. The company also develops solutions for non-profit organizations - Bill, and Melinda Gates Foundation and Drucker Institute, for example - and a considerable number of Americans prefectures. As stated by Bleicher (2015), IDEO through its founder, David Kelley, and its chief executive, Tim Brown, chose to share with society the methodology used for innovation and development of products/solutions, which culminated in the design thinking currently known.

According to Filho (2016), the methodology has, basically, three stages: (i) inspiration phase, which involves the full concerned of the problem, considering the needs, and behaviour of users; (ii) ideation phase, related to the generation of new ideas according to the context, and rapid and inexpensive prototyping of some of them, and; (iii) implementation phase, where the main ideas and prototypes for the development of a viable solution to the market are refining.

Therefore, in the understanding of Demarchi (2011) Design Thinking is a creative process based on the construction of ideas without judgments, eliminating the fear of failure, encouraging maximum absorption and participation of individuals in the process of solving problems. Although strongly associated with the business world, Bleicher (2015) elucidates that the real focus of Design Thinking is to make the human experience a tool at the service of Innovation, and it can be used in any situation, context or environment. It is a tool that uses the sensitivity, methods, design tools of designers to solve many types of problems, stimulating and developing empathy, creativity, critical thinking, reflection, transdisciplinarity, abstraction, and collaboration.

2.2 STEM

STEM education (Anachronism of English for science, technology, engineering, and mathematics) seeks to promote students' interest in the disciplines it covers, as well as develop the competence for solving problems and skills related to creativity, curiosity, resilience, communication, and collaboration (ATA-AKTÜRK; DEMIRCAN, 2020). Sen, Ay, and Kiray(2018) present STEM education as one of the most outstanding educational movements of recent years, providing a significant contribution to student development by emphasizing three key elements, and with a significant place on the agenda of all countries: problem-solving, innovation, and design.

Pugliese (2017) brings us that STEM education is a movement that was born in the United States, later spreading to other countries. The author also presents the three factors that justified, and catalysed the

movement: (i) the space that innovation acquired in societies, associated with techno-scientific transformations; (ii) international reports indicating poor performance and interest of U.S. students in various areas, including science, and; (iii) reports indicating that the U.S. was going through a shortage of skilled professionals in STEM areas, so that they would lose economic competitiveness as a result.

Thus, it is possible to realize that, together with the educational issue, there is an inherent economic concern, which justifies the interest of governments in stimulating and financing STEM education, as well as creating physical spaces, more proper pedagogical strategies that stimulate critical thinking, problem-solving, and the aptitude for the sciences in their school units.

3. Methodology

When faced with a problem or phenomenon, and we need to answer or to explain about it, we can only do this assertively through research that contains rational and systematic procedures. For this, there must be a process consisting of steps that cover the initial state, that is, the formulation of the problem or phenomenon until the final part, where the response or explanation of the phenomenon is presented (GIL, 2007).

The term Integrative Review comes from the idea of integrating ideas, opinions, concepts of concepts, works presented by different authors, studies, and therefore has the potential to create a holistic view of the theme of interest (WHITTEMORE; KNAF, 2005).

To reach the objective of this study, the use of an Integrative Review on the research issue was chosen because it is a method that creates a rigorous compendium of previous studies related to the proposed theme through a clear methodology, and easy reproduction (GREENHALGH, 1997).

The systematic search occurred in the multidisciplinary base's *Web of Science, and Scopus* recovering articles published with the terms related to the proposed theme. Articles published from 2014 to November 2020 were searched on both platforms. In these cases, we considered articles that are already accepted, approved, and published in scientific journals indexed in the databases described above, even if the date of release of the journals is set for the year 2021.

Inclusion criteria also entered: a) only articles in magazines, congresses, and conferences; and b) be available in free access, to ease the reading of the full article by the researchers.

The search terms were "*Design Thinking*", "*skill*", and "*children* "for search in the title, abstract, and keyword fields of the studies. The results of this first analysis created Table 01.

Table 01

Articles found by Platform

Base	Magazines	Conferences, and Congresses
Web of Science	19	12
Scopus	19	10
Total	38	22
General Total	60	

Source: Survey data, 2021

Using the *Software Mendeley Desktop*® (version 1.19.4) the articles were grouped for the analysis of possible duplicates. There were 41 articles for analysis, 24 published in magazines, and 17 in conferences, and congresses.

Once the inclusion criteria were established, the abstracts of all selected articles were read. After reading, 21articles were eliminated because they were not aligned with the scope of the theme of this research - didn't bring children as a study object, design thinking was used only as a method of conducting the research; Four articles were eliminated because they were not in English or because they were not freely accessible; one is not from a very specific field within the child's environment; one was literature review. Fourteen articles were left to be analysed more deeply by the authors. These were distributed in 11 journal articles, and 03 articles published in conferences or congresses.

Table 02 shows us the articles that were selected for this work.

Table 02

Articles Selected

TITLE	AUTHOR	GOAL	FINDINGS
3D Printing in the Wild: Adopting Digital Fabrication in Elementary School Education	Teemu Leinonen Marjo Virnes Ida Hietala Jaana Brinck	Create an overview of the use of 3D tools in the classroom, their opportunities, and obstacles	According to the teachers' observations, the 3D project aroused curiosity and generated motivation, even for those children who showed apathy to learn in other school subjects. However, it was not possible to observe all the expected gains in terms of creativity, and design due to limitations. In any case, it is believed that 3D printing projects in schools reach the full potential that the research community has addressed, but adopting them requires greater competence in the use of tools, pedagogical design, and greater understanding of the movement, and culture maker
An Analysis of the Nature of Young Students'	Anne Forbes Garry Falloon Michael Stevenson Maria Hatzigianni	Investigate learning processes, and the results of the use of 3D design, and printing technologies	Students were heavily involved in learning in the makers' spaces, and developed skills in several areas, including digital

STEM Learning in 3D Technology-Enhanced Makerspaces	Matt Bower	with children aged 5 to 8 in three schools in a metropolitan city of Australia	technical proficiency, design thinking, problem-solving, critical thinking, collaboration, and communication. The findings imply that 3D maker spaces, design, and printing can be used to promote literacy/knowledge in STEM
All Aboard for the Joy of Making! Teaching User-Centered Design, and Tinkering to Middle School Children in India	Vattigunta Susmitha Nagarajan Akshay Vilvanathan Vennila Anirudh Muraleedharan Rahul Nair Alekh Velayudhan Meltem Alkoyak-Yildiz Rao R. Bhavani	Assess the driving, and impact of a user-centric design workshop for eighth-graders at an Indian school	The workshop presented children with the concept of user-based product creation, and as a focal point for design decisions. Additionally, the children learned to use h, and tools such as the electric drill, saws, pipe files, sanding blocks, and skills such as painting, and pipe fixing. The results also indicate that the experience in the workshop increased the sense of efficacy by children, which can positively impact self-confidence
Amets Ekiten: A new entrepreneurial experience for primary education children	Arantza Arruti	Present a project called Amets Ekiten (Start-up Dreams) in which primary school children conduct workshops, and activities intending to develop entrepreneurial talent through skills such as creativity, innovation, solidarity, gratitude, and leadership	No results were presented in this study since it was intended only to elucidate the importance of entrepreneurial education in children, and how the Amets Ekiten project relates to this design.
Children's views on making, and designing	Maria Hatzigianni Michael Stevenson Matt Bower Garry Falloon Anne Forbes	Analyses interviews, and reports of children about their experiences with maker spaces, and digital tools, with emphasis on	According to the children's reports, it was possible to extract that their abilities evolved, but also their positive attitudes towards "doing", and the "creator mentality",

		the process of creation, and design	including important assets such as the willingness to try again, resilience, and persistence, even after failures. They also made many prototypes, responded to advice from colleagues, and challenged themselves to achieve their goals. The children were able to describe challenging, and rewarding aspects of their design, identify solutions, offer alternatives, and discuss innovative ideas. They were able to go from a passive posture concerning knowledge to active involvement with innovative ideas, and skills. Children came to see themselves as future designers, innovators, engineers, and scientists.
Children's engineering design thinking processes: The magic of the robots, and the power of blocks (electronics)	Sarika Kewalramani Ioanna Palaiologou Maria Dardanou	The study investigated two questions: 1. How do the introduction of littleBits, and associated electronic magnetic blocks exp, and the possibilities of play, and creativity of children with a focus on STEM? 2. What kind of critical thinking, and interdisciplinary STEM concepts have the children demonstrated?	The teachers, although not familiar to their technological pedagogical knowledge, engaged the children in playing with robotic toys, and co-they learned from them. The integration of playful experiences focused on STEM supported scientific research, design thinking, and children's creativity, as well as vocabulary directed to interdisciplinary STEM concepts. With an increasing focus on the development of children's skills of the 21st century, this study recommends that creativity and research arrangements should be considered in teaching and

			learning situations with young children.
Collaborative Design Thinking (CoDeT): A co-design approach for high child-to-adult ratios	Maarten Van Mechelen Ann Laenen Bieke Zaman Bert Willems Vero Vanden Abeele	Present the co-design approach of Collaborative Design Thinking (CoDeT), its theoretical framework, and its application in a case study with 49 children aged 9 to 10 years	To reap the benefits of co-design or collaborative creativity, multiple actors must work together on one or more goals. However, children often lack a basic understanding of the design processing of the design process, such that productive collaboration can be difficult to achieve, especially when children lack the motivation or skills to work as a team. This is even more complicated in co-design environments with a high child-to-adult ratio. The CoDeT approach helps to address this difficulty by allowing children to work relatively independently of adults in co-design activities.
Effect of design thinking approach on students' achievement in some selected physics concepts in the context of STEM learning	Moses Irekpita Simeon Mohd Ali Samsudin Nooraida Yakob	Investigate the impact of a design thinking-based teaching method on male, and female students, under concepts of physics discipline in the context of STEM learning	Students of both sexes improved their performance, but male participants had higher scores than women when STEM design thinking modules were used to learn physics concepts. Implications include the need to training physics teachers in the use of a gender-balanced STEM design thought pedagogy. This training should guide teachers on how these STEM design thinking modules can be used to create opportunities by linking learning physics concepts to real-life situations

Future entrepreneurs design a way: Supporting product innovation with a design thinking approach in a children's extracurricular sewing programme	Annie Botha Thea Tselepis Lee de Wet	Explore the role/impact of activity focused on product innovation in participants of an extracurricular sewing program	Design Thinking principles, aligned with the dimensions of creativity, can encourage product innovation, and allow participants to freely experiment, and develop product prototypes with the intention of enterprise design
Identity negotiation within peer groups during an informal engineering education program: The central role of leadership-oriented youth	Scott A. Pattison Ivel Gontan Smirla Ramos-Montañez Lauren Moreno	Peer interactions are a learning characteristic, both inside, and outside the classroom, for children, and young people, and identity processes shape the ways young people come to see themselves, including STEM topics, and careers. Thus, the objective of the research was to evaluate how participants with a leadership profile influenced the identity negotiation of their peers and the mechanisms by which the young people provided, and restricted identity negotiation within the groups.	Young people with leadership profiles exert a profound influence on the other members of the group concerning how they see themselves, and what they develop in engineering activities. In such a way, this condition should be considered in education programming based on STEM concepts.
Improving creative ability of base of pyramid (BOP) students in India	C. Parikh K. Maddulety CJ Meadows	Investigate how to prepare children from the Base of the Pyramid in India for creativity through Design Thinking-based training	Results showed a significant general difference in the scores of creative ability indicators of students who received intervention concerning those who did not. The study

			recommended that socio-technological entrepreneurs in the country become protagonists, and stakeholders for the development of creative skills for students at the base of the pyramid
Integrating Design-Based Learning Methodologies in Rural Educational Environments in Chile: A Positive Collaborative Model at the Head of the Action!	Mr. Menezes J. Alarcón L. Navarrete P. Bello R. Montecino N. Mardones J.P. González	Presents the results of an experiment conducted under the research project "Development, and small-scale validation of a didactic model to improve the effectiveness, and efficiency of teaching-learning processes in rural schools in Chile". The project aims to integrate design-based learning methodologies (DBL) that are based on the integration of design thinking and the design process in the classroom into primary schools.	Students demonstrated the ability to detect authentic problems in their community by asking questions about three different, and complementary topics: recycling, animal care, and forest care. The teachers responsible for guiding the activity found that the chosen themes were in line with the needs for community improvement and that the students had succeeded in their decision, as they effectively required a solution to the problems of domestic waste treatment, care of pets threatened by wild animals, and forest care, and wood extraction. The students were able to propose various ideas to solve problems, with creative, and imaginative ideas, respecting reality.
When Kids are Challenged to Solve Real Problems – Case Study on Transforming Learning with Interpersonal Presence, and	Renate Motschnig Daniel Pfeiffer Anna Gawin Peter Gawin Michael Steiner	Assess how computational thinking, and digital, and interpersonal skills can be effectively promoted in schools with traditional structures, with the Stanford Children's Design Thinking Method	The results show that students have learned significantly, both in programming, and social skills, and most enjoy this type of active learning. The results also clearly indicate that - although the intervention is child-centered - their teachers need to be heavily included,

Digital Technologies			otherwise a notable part of them may lose control over the class and remain skeptical
Young children's design thinking skills in makerspaces	Maria Hatzigianni Michael Stevenson Garry Falloon Matt Bower Anne Forbes	Assess how children from kindergarten to second grade (children aged 5 to 8 years old, three classrooms) designed and printed 3D objects using tablets, printers, and physical materials, using the five steps of IDEO's Design Thinking model	Design thinking approaches are suitable, and beneficial for young children, and can enhance open, flexible, and transferable skills such as creativity, and critical thinking. Consistent with learning expectations for the future, developing design thinking skills in young children can help equip them with the right skills to 'strategically manage their challenges in the digital age

Source: Survey data, 2021

4. Analysis of Systematic Search Results

We can observe from Table 03 that there is possible recent concern about the subject studied since there is a predominance of articles written in the year 2020, with seven articles, and two more articles that will be in journals in the year 2021, but that are already available by the journals on their websites for analysis by researchers. There was no journal or event with more than one article selected for this study.

Table 03

Relevant articles per year

Year	Quantity
2014	01
2015	00
2016	00
2017	01
2018	03
2019	01
2020	06
2021	02

Source: Survey data, 2021

It should also be emphasized that there were 51 different authors in the articles, with only one study with a single author. All the other analysed studies had at least three authors. We should highlight 05 authors who take part in 03 different articles. These articles are part of the same research project, from Australia, but have different goals. All other authors participate in a single paper.

The research described in the articles is spread throughout Europe (04), Asia (02), Oceania (04), North America (01), South America (01), and Africa (02). Among the countries with analysed surveys, Australia stands out, with all 03 referring to the same project, as mentioned above. India also stands out, where 02 kinds of research analysed in the articles were conducted.

Within the keywords of the articles, we found 60 distinct types of expressions to give life to the articles. The most used was *Design Thinking, and Creativity as* we can see in Figure 01.

Figure 01 - Keyword Word cloud

Source: Survey data, 2021

5. Discussion

The articles analysed somehow bring the STEM as a fundamental point for their studies. Not for less, as we have seen, these skills are considered essential for basic education in this century. These skills were not always present in the articles explicitly, but they always approached areas covered by the acronym.

Also, during the analysis of the works, it was noticed that design thinking was not necessarily presented to children and adolescents as a methodology to be followed for problem-solving. However, in a portion of the articles, educators conducted children's activities that permeated the main stages of Design Thinking, such as the debate and understanding of the problem, ideation/prototyping, and the development of a solution.

Forbes *et al.* (2021), and Hatzigianni *et al.* (2020, 2021) bring in their articles the project *The Makerspaces in Primary School Settings* where through design activities, modelling, and 3D printing

analysed the learning skills of the 21st century, especially those focused on STEM. In a universe of more than 550 children aged 05 to 08 years, the tools for the development of tasks were presented. Teachers were instructed by facilitators within the Design Thinking perspective in the parameters of the Innovation Design Engineering Organization (IDEO). A development was observed in issues such as engagement, collaboration, communication, and creativity. Although there is no good evidence that students have developed skills in issues such as Design Thinking or critical, and reflective thinking, for example, the authors agree that educational innovations are promising in early childhood. Parikh, Maddulety, and Meadows (2020), in a different study, follow the same line of conclusion, adding that language can be a limiting factor for the expression of ideas for some children.

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