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A transversal and practical education as a business success factor: literature review of learning process of basic design through ICT tools

Una educación transversal y práctica como factor de éxito empresarial: revisión de la literatura relativa al aprendizaje de diseño básico a través de herramientas TIC

Javier Turienzo*
https://orcid.org/0000-0003-4861-7440 (ORCID iD)
University of Santiago de Compostela (Spain)

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*Corresponding author: javier.turienzo@usc.es
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ABSTRACT

The ongoing societal transformation propelled by innovation and digitalization is amplifying the demand for technological adeptness among current and upcoming professionals. Consequently, there's a pressing need to revamp the educational system and its methodologies to elevate the requisite skill set. Spatial reasoning, innovative thinking, and creativity stand as pivotal proficiencies essential for enabling future professionals to swiftly craft adaptable prototypes catering to client needs. However, conventional teaching approaches exhibit shortcomings in nurturing spatial reasoning, necessitating deeper exploration within the realm of education. This study delves into novel 3D design tools aimed at facilitating three-dimensional modelling within educational settings. The findings underscore the imperative use of digital tools in crafting 3D objects, fostering the development of spatial visualization skills. Moreover, they emphasize the significance of intertwining ICT knowledge, programming skills, and pertinent soft skills. Such an amalgamation equips future professionals with enhanced work capabilities, a comprehensive grasp of market needs, and refined product commercialization strategies.

Keywords. Education, Marketing Mix, spatial, reasoning, software, geometry

RESUMEN

La transformación social en curso impulsada por la innovación y la digitalización está amplificando la demanda de competencia tecnológica entre los profesionales actuales y futuros. En consecuencia, existe una necesidad apremiante de renovar el sistema educativo y sus metodologías para elevar el conjunto de habilidades necesarias. El razonamiento espacial, el pensamiento innovador y la creatividad son competencias fundamentales que permiten a los futuros profesionales crear rápidamente prototipos adaptables que satisfagan las necesidades de los clientes. Sin embargo, los enfoques de enseñanza convencionales presentan deficiencias a la hora de fomentar el razonamiento espacial, lo que requiere una exploración más profunda dentro del ámbito de la educación. Este estudio profundiza en novedosas herramientas de diseño 3D destinadas a facilitar el modelado tridimensional en entornos educativos. Los hallazgos subrayan el uso imperativo de herramientas digitales en la creación de objetos 3D, fomentando el desarrollo de habilidades de visualización espacial. Además, enfatizan la importancia de entrelazar el conocimiento de las TIC, las habilidades de programación y las habilidades interpersonales pertinentes. Esta fusión dota a los futuros profesionales de capacidades laborales mejoradas, una comprensión integral de las necesidades del mercado y estrategias refinadas de comercialización de productos.

Palabras clave. Educación, Marketing Mix, espacial, razonamiento, software, geometría.

INTRODUCTION

The technologies and innovation that characterize the 21st century are increasing the demand for highly skilled personnel in technology and sciences. However, for decades, there has been concern regarding the apparent reluctance of social science students towards STEM subjects (Science, Technology, Engineering, and Mathematics) from an early age (Osborne et al., 2003). Despite perceiving their benefits (such as healing capabilities and technological advancements) and holding a positive view of science (Potvin and Hasni, 2014), students tend to shun scientific studies due to their complexity and learning methods (Murphy and Beggs, 2003). Consequently, students' negative attitudes diminish their ability and competency in product design and understanding customer needs (Barmby et al., 2008).

Concurrently, soft skills (e.g., empathy, teamwork, self-management, commitment) are considered highly valuable in the development of science and team-based problem-solving, as well as through entrepreneurship and broadening research perspectives (Luzardo and Peña, 2006). Furthermore, studies reinforce the perception that the rejection of scientific professions is more critical among females than males (Murphy and Beggs, 2003), contributing to a gender gap.

In the scientific and educational realm, a multitude of techniques have been analyzed, among which gamification or interactive teaching based on small student groups stand out, maximizing theoretical and practical outcomes and the acquisition of soft skills (Park and Leung, 2006), while fostering female entrepreneurship (Turienzo, 2022). However, in recent decades, teaching has artificially separated marketing techniques from core knowledge areas like geometry (Mulligan, 2015), despite their significant impact and connection to the marketing mix (Greenleaf and Raghubir, 2007).

The intricate composition of objects necessitates teaching students spatial vision skills. Spatial vision, critical for developing two variables of the marketing mix (distribution and product; Goi, 2009), involves the mental activity enabling the creation and manipulation of spatial images during practical and theoretical problem-solving (Uttal et al., 2013). It includes rotating objects in 2D or 3D to a specific angle clockwise or counterclockwise (Bruce and Hawes, 2015). Hence, spatial thinking plays a crucial role in preparing marketing professionals reliant on understanding and relationships within 3D objects (Greenleaf and Raghubir, 2007). Students with high three-dimensional spatial understanding skills present better results in complex operations like product design (Liao, 2017). Therefore, to enhance students and future professionals, emphasis should be placed on improving their spatial thinking abilities (Clements, 2004). These spatial skills encompass understanding object perception from different angles, mental construction and maintenance of images, and rotating and transforming shapes mentally (Uttal et al., 2013). Additionally, cognitive processes involved in spatial thinking include decomposing features, rotation, folding, generating orientation hypotheses, and verifying or checking hypotheses (Hegarty and Waller, 2005).

The significance of spatial thinking motivated the study of its relevance in marketing education within schools (Ganesh et al., 2010) and businesses (Ramful et al., 2017). Due to its importance, some researchers and educators introduced the use of origami for improving students' spatial thinking skills through simple paper-folding activities (Verdine et al., 2014). Simultaneously, the application of ICT tools and smart devices is increasingly accessible to the general public and educational institutions for communication and entertainment purposes (Kearney et al., 2015). Moreover, ICT tools provide significant advantages in the education process due to their proximity, updates, and approachability in possible projects (Trust and Maloy, 2017). Consequently, 3D modelling is being considered as a substitute for origami in the teaching process. Through a structured approach and a brief demonstration by the teacher (facilitator) of the 3D object creation process, students can autonomously create objects interactively and collaboratively on their computers (Kostakis et al., 2015). Furthermore, there is the possibility of generating a real model with the help of 3D printing.

Virtual platforms (such as TinkerCAD and Google Classroom) offer experiences akin to conventional laboratory activities (Potkonjak et al., 2016). Additionally, educational platforms like Scratch, Sketch Up, or TinkerCAD are easy to explain and learn (Avila and Bailey, 2016) and enable advanced functionalities based on hardware devices (Ng and Sinclair, 2018). Altogether, these tools are poised to become the future of education owing to the levels of student acquisition and satisfaction in being able to design and create something new (Dere and Kalelioglu, 2020). However, technological integration to support teaching and learning in the classroom is influenced by teachers' attitudes and pedagogical beliefs (Perrotta, 2013).

Various recent studies with students demonstrated that the 3D modeling process helps develop spatial awareness skills (Šafhalter et al., 2016), with the potential for training through 3D modelling practice (Ng and Chan, 2019). The creative and educational potential of 3D printing and modelling makes it an excellent platform for students to design and print their 3D products, creative spaces, and libraries (McNally et al., 2017), further enhancing their creativity, spatial thinking, and problem-solving skills (Trust and Maloy, 2017). In this regard, numerous notable educational developments are ongoing. Projects based on Augmented Reality have demonstrated their abilities to support the 3D modelling process in teaching (Bower et al., 2014).

Consequently, developing educational activities using 3D design and modelling software and 3D printers can be employed in the classroom to support learning (Eisenberg, 2009; Ford and Minshal, 2018; Ng and Chan, 2019). This educational proposal, called 'making', supports contextualized learning and deeply engages students in interdisciplinary projects (Trust and Maloy, 2017). Often, this approach is developed alongside the teacher's role as a facilitator of the 3D modelling curriculum to prevent student distraction (Kostakis et al., 2015). Thus, like any educational strategy, it needs to be implemented through thorough reflection considering various existing alternatives.

Technological innovation has provided numerous resources for education. However, different platforms and 3D modelling software exhibit disparate perspectives, capabilities, and features. Hence, there is a need to study and compare the characteristics of the primary software and platforms (GeoGebra, TinkerCAD, Sketch UP, Scratch, and Blender) from an educational perspective.

With this intention, an in-depth literature review will be conducted in the educational field related to different software and platforms. Additionally, a simulation of an educational activity will be developed through these software and platforms to analyse their respective advantages and disadvantages.

Therefore, this article aims to analyse how new educational tools (3D modelling) can be applied to maximize technical-practical capabilities and professional skills in future graduates from marketing schools. To achieve this, the research is organized into a second section delving into the methodology employed to analyze the studied and tools concerning. Subsequently, the review of the theorical framework details the theory associated with educational modelling tools. Following this, the research results are outlined. The fourth section introduces the discussion, and finally, implications of the research and the main conclusions are drawn.

METHODOLOGY

The present research conducts a review of existing literature and scientific studies regarding the use of 3D design and printing tools in mathematics education. To achieve the objective, a study based on the Systematic Literature Review (SLR) technique was employed. SLR is a research technique that allows for the evaluation and synthesis of published and relevant studies to address a specific research question or objective (Kitchenham and Charters, 2007). The use of SLR enables the acquisition of detailed, objective, and reasoned information from multiple perspectives and experiments (Gurbuz and Tekinerdogan, 2018). Therefore, this methodology is widely utilized in the analysis of technologies (Kitchenham and Charters, 2007), education (Martin et al., 2020) y business (de Oca et al., 2015). Despite the indicated benefits of SLR, the methodology required a manual effort to review the text, being recommended to follow a structured work methodology and support of ITC tools (Marshall, 2016). Finally, the required time to develop the analysis implies the existence of a medium-large period previous the publication that last research can not been studied (Elliott et al., 2014; Shojania et al., 2007).

In accordance with Kitchenham and Charters (2007), to successfully apply the SLR technique, it is advisable to follow 12 stages or phases that are grouped into three blocks: (1) Need for a review; (2) Conducting the review; (3) Reporting the review. As the initial step of the second phase of the methodology, a search was conducted for existing articles in the field until July of 2023. However, in an effort to enhance the reliability of the results and subsequent conclusions, publications lacking scientific rigor were excluded. Similarly, the search and analysis were confined to articles published in Spanish and English scientific journals. To perform this task, the following websites were utilized: Google Scholar and Business Source Premier (EBSCO).

The search employed Boolean searches with the following terms: TinkerCAD, SketchUp, GeoGebra, Scratch, Blender, and 3D printing combined with Education, thinking, School, Secondary, business and university. Additionally, the search was limited to articles published from 2010 onward. These terms could appear in the article titles, abstracts, and within the body of the text. In the second stage of the research, a similar search was conducted, focusing on recent articles (from 2010 onwards). Due to the extensive body of literature, priority was given to analysing peer-reviewed studies or articles (see Table 1).

Table 1: Search results according to the terms used and searchs filtres

Terms Employed	Title (articles)	Title + Abstract (articles)	Title + Abstract + Body (articles)	Title + Abstract + Body (since 2010) (articles)
TinkerCAD & Education or thinking or School or Secondary or business or university	• EBSCO: 0 (0)	• EBSCO: 1 (0)	• Google Scholar: 1,020 (30) • EBSCO: 2 (0)	• Google Scholar: 1,060 (31) • EBSCO: 2(0)
Sketch Up & Education or thinking or School or Secondary or business or university	• EBSCO: 0 (0)	• EBSCO: 1 (0)	• Google Scholar: 3,260 (98) • EBSCO: 4 (0)	• Google Scholar: 3,550 (94) • EBSCO: 4 (0)
Scratch & Education or thinking or School or Secondary or business or university	• EBSCO: 0 (0)	• EBSCO: 165 (17)	• Google Scholar: 20,500 (13,600) • EBSCO: 614 (159)	• Google Scholar: 18,200 (8,930) • EBSCO: 404 (115)
Blender & Education or thinking or School or Secondary or business or university	• EBSCO: 0 (0)	• EBSCO: 12 (1)	• Google Scholar: 18,200 (3,540) • EBSCO: 46 (10)	• Google Scholar: 17,400 (2,310) • EBSCO: 26 (7)
3D printing & Education or thinking or School or Secondary or business or university	• EBSCO: 13 (0)	• EBSCO: 126 (4)	• Google Scholar: 18,700 (18,400) • EBSCO: 932 (208)	• Google Scholar: 17,600 (17,300) EBSCO: 663 (148)

After analysing the articles and previous research, as presented in the previous section titled Literature Review a design test was conducted using the analysed software tools and freely accessible platforms. As a test of the functionalities of the different software analysed and free-access platforms, a design phase of an item (keychain) was carried out. This phase aimed to evaluate the features of the tools, their advantages, and disadvantages for accomplishing simple design tasks and subsequent 3D printing, using a keychain with similar characteristics as the evaluative object.

REVIEW OF THE THEORETICAL FRAMEWORK

Use of 3D modelling tols

In recent decades, education has significantly evolved to incorporate interactive teaching-learning techniques and the use of ICT tools. 3D modelling associated with technological tools facilitates students' acquisition of STEM, CC, CP, CE, CCEC, CPSAA, and CD competencies (Lobato and Sato, 2019). Additionally, 3D modelling allows students to independently construct projects (Lobato and Sato, 2019).

3D modelling tools such as TinkerCAD (Cline, 2014) and Sketch Up (Jiawei and Mokmin, 2023), along with 3D-focused instructional materials and training programs, are available for novice 3D modelers. However, learning 3D modelling can still be daunting, requiring a serious time commitment and mastery of the technology (Kelly, 2014). Students need fundamental learning in geometric tools and ICT tools to aid them in classroom activities (Nemorin and Selwyn, 2017).

Moreover, students enhance their ability to develop innovative solutions and prototypes or replicas of everyday products (Lobato and Sato, 2019). We combined digital manufacturing, fabrication, and entrepreneurial education in a school-based innovation project involving adolescents (Trust and Maloy, 2017). In this regard, the validity of an eight-week 3D printing curriculum developed using an instructional design approach called storylining was demonstrated (Reiser, 2014).

Finally, the use of modelling tools through design and an integrated approach to teaching geometry in peer coaching allowed teachers to enhance their skills and students to improve their understanding in learning (Lu, 2010). Furthermore, the use of software assists teachers and students in executing, exploring, interpreting, and enhancing student performance (Bridson et al., 2013; Naidoo and Govender, 2014).

Digital manufacturing projects also allowed understanding and identifying relevant and useful aspects associated with the curriculum based on experimentation, as well as associating feelings of success or issues collectively (Ford and Minshall, 2018). In virtual laboratories created from design tools, educational projects can be conducted with higher learning rates (Potkonjak et al., 2016). Simultaneously, the assumption of roles and responsibilities in projects generates expectations in students that enable responsible, innovative, and entrepreneurial learning in a digitized future (Trust and Maloy, 2017). Students engaged in digital manufacturing projects (modeling and construction) displayed a shift in routine and behaviour (Pearson and Dubé, 2022). Consequently, a geometry-based dynamic project environment is crucial for the teaching and learning of mathematics, allowing students to explore both geometry and algebraic representations of content structure and aiding in interpretation (Zengin, 2019).

GeoGebra

GeoGebra stands out as a technological tool for its remarkable effectiveness when applied as instructional material in the design and understanding of geometric shapes (Ju et al., 2020). Consequently, the GeoGebra software is utilized as a technological tool to enhance both theoretical and practical forms of teaching and learning, resulting in improved performance and conceptual understanding (Yohannes and Chen, 2021).

Moreover, the effectiveness in teaching and learning associated with GeoGebra is highly correlated with increased interest during the teaching process. According to Yohannes and Chen (2021), a significant portion of GeoGebra's effectiveness lies in enhancing learning outcomes. Hence, it enhances students' understanding of mathematical concepts through the development and application of real-life problems (Aktumen and Bulut, 2013). In this regard, Niyukuri et al. (2020) asserted that using GeoGebra in geometry learning assists students in visualizing and comprehending content through exploration. Apart from the positive responses and enhanced learning outcomes, students' ability to visualize necessary images to solve various geometric challenges increased, thereby reducing difficulties in constructing geometric shapes (Ju et al., 2010).

Literature reveals that students taught using GeoGebra software for design-based learning achieve better results compared to those taught through traditional methods (Tutkune Ozturk, 2013; Tomić et al., 2019). Studies such as Uwurukundo et al. (2022) demonstrated that students learning with GeoGebra software had advantages and outperformed their counterparts who did not learn with this software. A significant part of this success lies in the visual nature and transferability of knowledge to GeoGebra skills, as students can view and manipulate on the computer (Aktumen and Bulut, 2013).

TinkerCAD

Tools like Autodesk's TinkerCAD provide a lower entry barrier with fewer unfamiliar terms and simpler geometry (Kelly, 2014). TinkerCAD serves as a tool that offers students of all ages a solid introduction to 3D printing technology (Ng and Chan, 2019). Consequently, 3D modelling tools like TinkerCAD and SketchUp are utilized by primary and secondary students (Kelly, 2014). The new virtual context, based on CAD software like TinkerCAD and subsequent printing, enables students to create their own designs during the learning process (O'Reilly and Barry, 2023).

Students activate geometric knowledge (procedures) and the ability to manipulate and explore during the design process (O'Reilly and Barry, 2023). Consequently, TinkerCAD combined with augmented technology allows students to observe their work almost in real-time (Altmeyer et al., 2020).

Simultaneously, the combination of 3D design and printing favours constructive solid geometry (CSG), making the teaching of TinkerCAD linked to the use of 3D printers reveal highly favourable results (Avila and Bailey, 2016). In this regard, the fusion of thinking, design, and production holds immense potential to enhance motivation and satisfaction, with a highly probable increase in educational achievements (Ford and Minshall, 2018).

On the other hand, results indicated that mental rotation skills, as measured by the instrument, were improved by the CAD intervention (Williams and Capraro, 2020), enabling the creation of customer-centric and logistically efficient products. Free web access to 3D modelling tools like TinkerCAD allows adolescents to execute projects and prototypes, develop soft skills (Lobato and Sato, 2019), and enhance their reflective capacity (Trust and Maloy, 2017).

Sketch Up

SketchUp is software that enables the creation of 3D geometry through a sequence of stages, starting with 2D primitives and allowing users to push and pull them into 3D. This grants students a heightened sense of control over their creations while also eliminating some of the abstract entities associated with starting from pre-made 3D primitives (Ávila and Bailey, 2016). This circumstance enables students to visualize the objects created and achieve better design expectations and learning outcomes (Hajirasouli and Banihashemi, 2022). Lastly, akin to TinkerCAD, the combination of utilizing printing technology and the CAD program SketchUp among school students enhances performance in geometry classes and precision (Chapman and An, 2017).

Blender

The development of educational software has led to the emergence of other tools like Blender, which doesn’t have a specifically educational purpose. It’s an open-source professional package for modelling, rendering, and animation. Older students can create highly complex designs, but it requires more effort to get up to speed (Avila and Bailey, 2016), hence recommended for more advanced courses or later stages like high school or university.

Augmented reality through Blender has the potential to be an effective tool for studying formal content (Mystakidis et al., 2022). Consequently, the use of augmented reality through Blender provides better comprehension of concepts compared to traditional methodologies (Skulmowsk et al., 2021). Furthermore, since Blender can be used to teach coordinate spaces, it is particularly recommended for students interested in product distribution.

3D printing machine

3D printing is becoming increasingly prevalent in daily life, particularly in fields such as engineering, science, architecture, healthcare, the food industry, fashion, and education (Pearson and Dubé, 2022). 3D technologies offer a deeper understanding of knowledge due to the connection between theoretical lessons and printed objects (Bower et al., 2014).

While 3D printing education is gaining momentum, researchers are exploring the interaction of new students with these technologies (McNally et al., 2017). Traditionally, newcomers to these technologies, regardless of age, often found them daunting due to usability and learning issues (Posch and Fitzpatrick, 2012; McNally et al., 2017; Pellas et al., 2021). However, both 3D printing and modelling technologies are becoming more user-friendly for newcomers, with various applications introducing these technologies (Kelly, 2014). On the other hand, the market availability of basic or home 3D printers such as Lulzbot and Makerbot is easy to use, often employed in education, or even as personal manufacturing technologies in households (Kostakis et al., 2015). As a result, open-source 3D printing technologies have the potential to enhance education by actively engaging students with these technologies, providing a sense of empowerment and cross-disciplinary commitment (Trust and Maloy, 2017). Furthermore, 3D printers inherently possess the ability to create tangible artifacts from digitally generated 3D designs (Radniecki, 2017).

Moreover, since 3D printing also requires a 3D model, users need to acquire or update some prior knowledge to become successful modelers (Minetola et al., 2015). However, as a result of its use, it helps develop broad competencies in high school students, including (i) computational thinking (Ford and Minshall, 2019); (ii) design thinking (O'Reilly and Barry, 2023); (iii) mathematical skills (Jackson, 2017); and (iv) soft skills that enhance students' self-esteem, collaboration, play, and self-expression (McNally et al., 2017). Additionally, depending on the object to be designed, it has the capacity to provide extra motivation to study theory and concepts through experimentation (Minetola et al., 2015).

Issues associated with teaching through the use of technology

Mathematics education through ICT is heavily influenced by the typology and design of digital tools, their educational usability, and the educators' knowledge (Ertmer et al., 2012). This poses challenges for educational institutions and faculty (Clark-Wilson et al., 2020), necessitating the involvement of regulators and educators.

In this regard, students encounter difficulties in effectively using the tool when tasks and projects are individualized, leading them to compete rather than follow integrated instructions from teachers and technological assistance (Viberg et al., 2020). Consequently, there is an added task rather than harnessing the pedagogical potential of the tool, the teacher's role, and the educational context (Ertmer et al., 2012).

On the other hand, experts note that although governments invest in infrastructure and technology, opportunities to use technology are often hindered by administrative issues such as scheduling, lack of time for skill development, and limited options for platforms and systems to work with (Adler, 2000; Trouche et al., 2020).

General issues associated with 3D education

Early systems' complexity, design tools, and 3D printers increased the rate of flawed or defective parts. These issues in 3D printing were primarily due to misprints resulting from voids, discrepancies between shapes, and/or misalignments among the shapes (McNally et al., 2017). These problems contributed to early discomfort and insecurity among teachers and facilitators in teaching 3D printing and modelling to new students (Buehler et al., 2016).

Moreover, informal discussions in numerous centers highlighted insufficient high-quality 3D resources focused on students (Ford and Minshall, 2018). Consequently, there's a lack of adequate means for teachers to use when teaching 3D modelling and printing in classrooms. Regarding the use of Software as a Service (SaaS) design tools, issues arise concerning connectivity (Akçayır et al., 2016). However, the challenges associated with the COVID-19 pandemic prompted a clear and decisive push for connectivity in the field of education (Engelbrecht et al., 2023).

Furthermore, the combination of using printing technology and CAD programs could present various challenges related to virtual activity and technical issues (Ford and Minshall, 2018). Similarly, 3D modelling tools were not adapted to the specific needs of teaching and, consequently, caused aversion among students (Zhou et al., 2022). As a result, the scarcity of resources (Ford and Minshall, 2018) accentuates the need for teacher training (Clark-Wilson et al., 2020). Therefore, considering that one of the initial steps for 3D printing is designing a model within CAD software, students struggle with software orientation, perspectives, floating shapes, and camera control (Posch and Fitzpatrick, 2012; McNally et al., 2017).

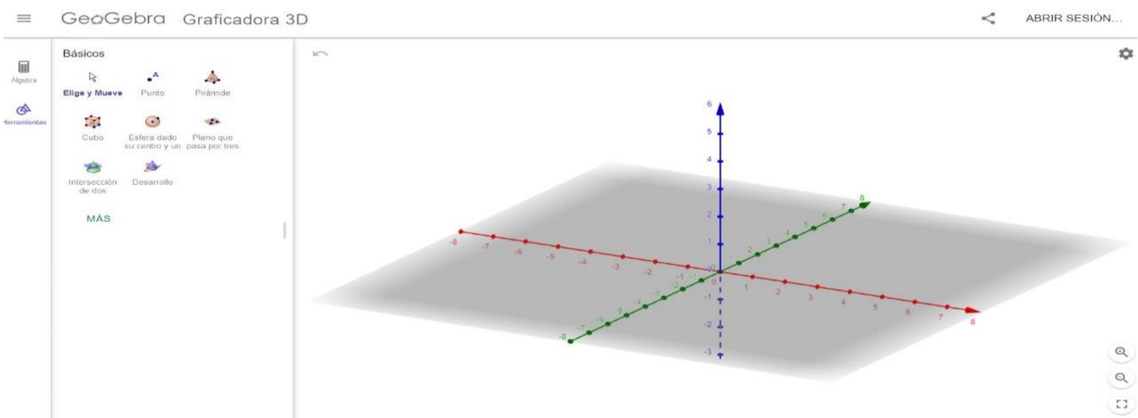
Nevertheless, teachers may face challenges in applying technology in classroom teaching through professional cooperation (Bozkurt and Uygan, 2020). Through cooperation, teachers can overcome difficulties by implementing technology-based lessons for effective teaching and learning (Lu, 2010).

TESTING OF THE MOST FAMOUS ICT TOOLS

Geogebra

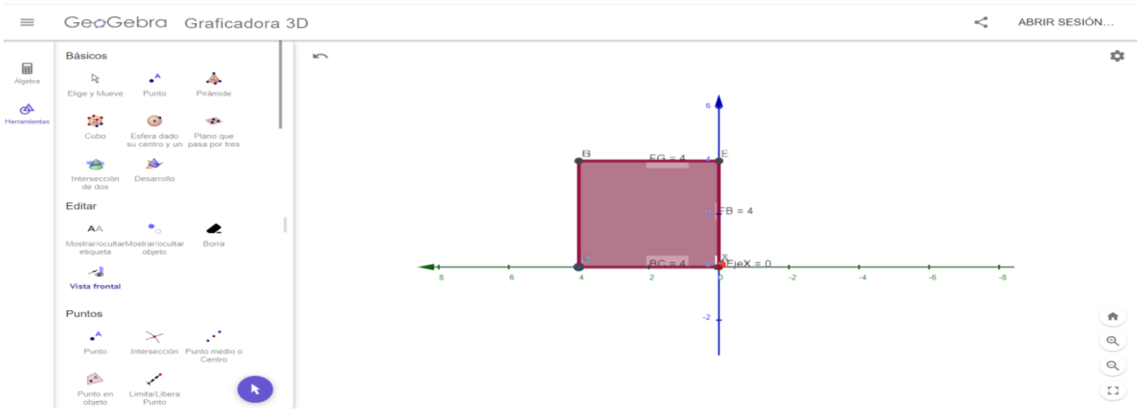
The initial design, conducted in GeoGebra, began with an exploration of the tool and its features. Initial impressions reveal a clean design that allows students to start working with basic geometric shapes (see Figure 1). GeoGebra provides a brief description or explanation of the functionality of each design feature, aiding and reducing students' adaptation time to the tool.

Figure 1. GeoGebra's clean design.



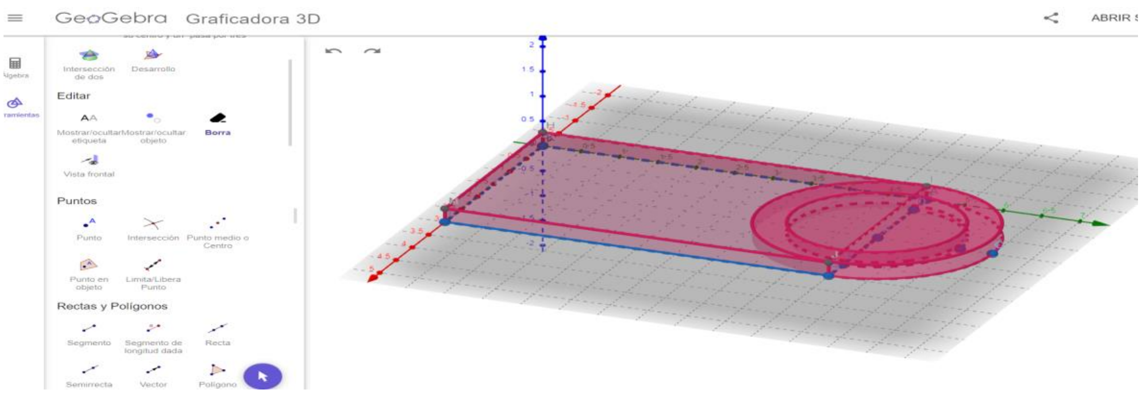
However, the tool offers a wide range of design options enabling the creation of complex designs (see Figure 2). Additionally, it provides a calculator associated with geometry, allowing calculations of areas, volumes, etc., promoting a relational understanding of mathematics through design and spatial visualization.

Figure 2. Geogebra design options.



GeoGebra's design of simple figures allows students to create 3D objects in a straightforward manner (e.g., cubes, spheres) or from two-dimensional shapes (e.g., polygons, circles). It also enables the rotation of views between 3D and 2D perspectives. However, it has limitations, such as the inability to include text with 3D relief (see Figure 3).

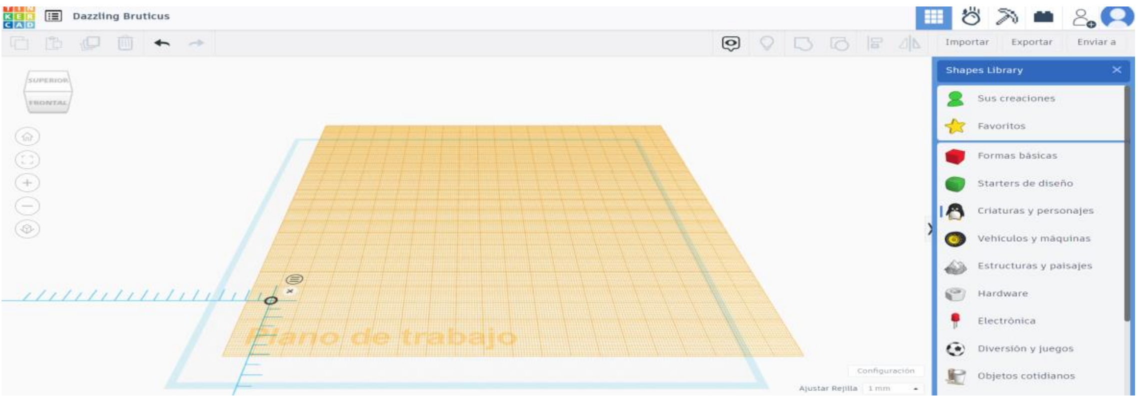
Figure 3. Ending of process in GeoGebra.



TinkerCAD

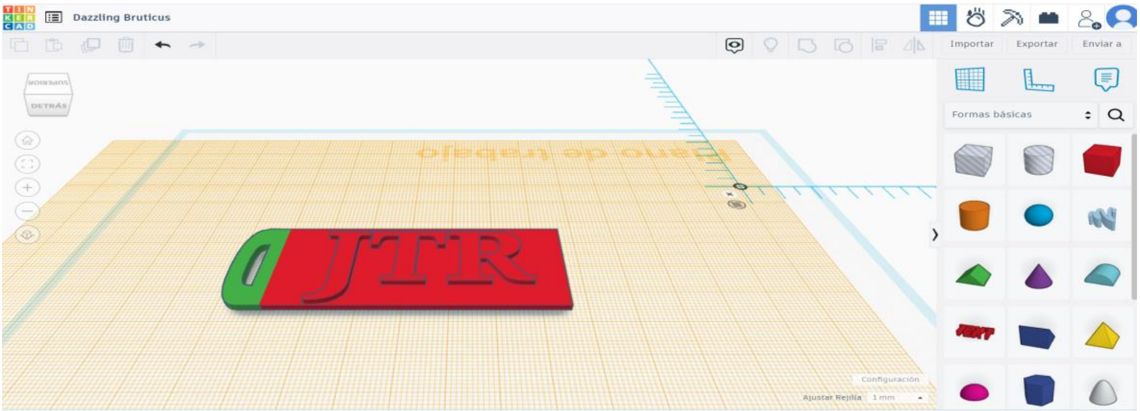
TinkerCAD is a tool that allows more complex designs by combining simple elements that can be unified. Moreover, it enables the inclusion of texts or everyday life objects with volume for subsequent printing or use in other design software (see Figure 4).

Figure 4. TinkerCAD Object Library.



The tool facilitates achieving complex shapes and designs (see Figure 5) by combining simple geometric shapes. However, it's not possible to create a completely free design as in other educational design tools.

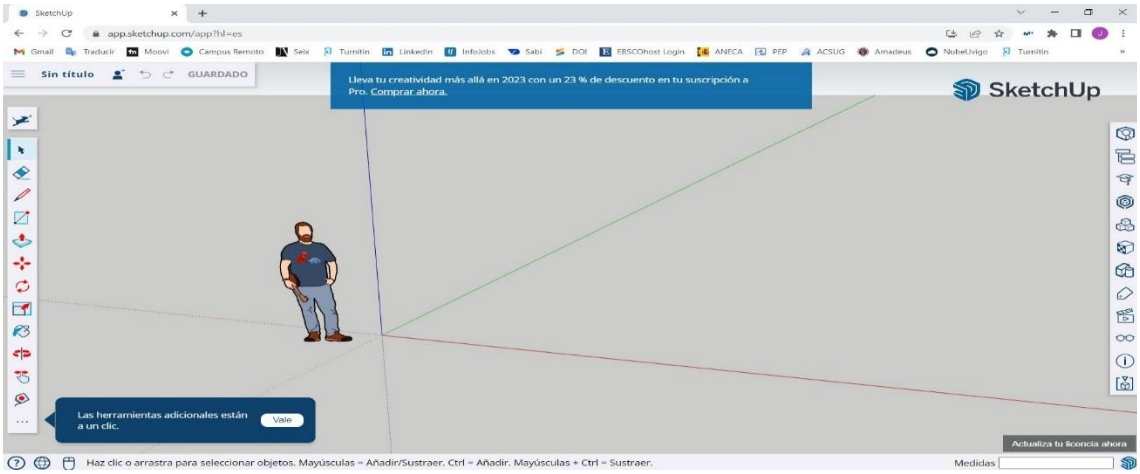
Figure 5. Final design TinkerCAD.



Sketch Up

SketchUp presents a highly specialized visual aspect, similar to CAD software used for professional design. However, its use is quite intuitive due to the welcome messages and guidance in the initial steps, as shown in Figure 6.

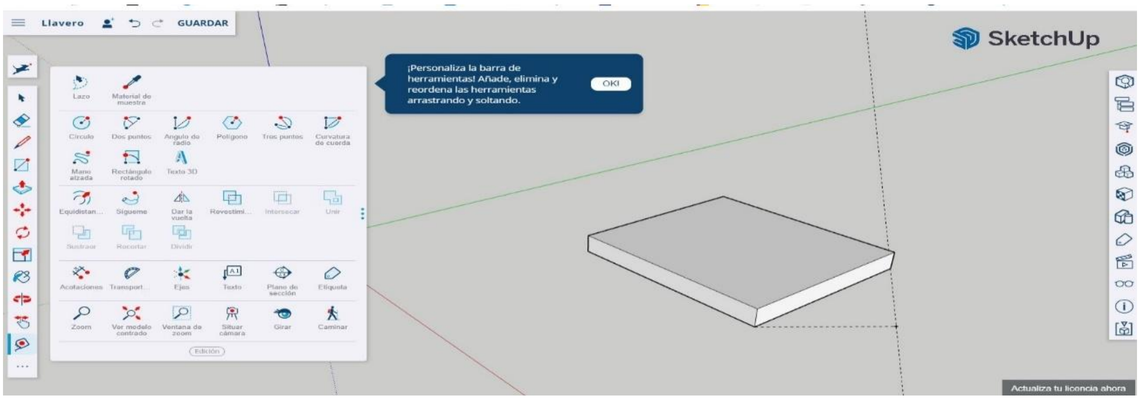
Figure 6. Mensaxes de axuda inicial Sketch Up.



On the other hand, it's important to note that the tool must be configured by the student, posing an issue for the school stage. Conversely, the need to configure the measurement units to the metric system enables students to perform conversions between inches and centimetres, making the design stage more interdisciplinary.

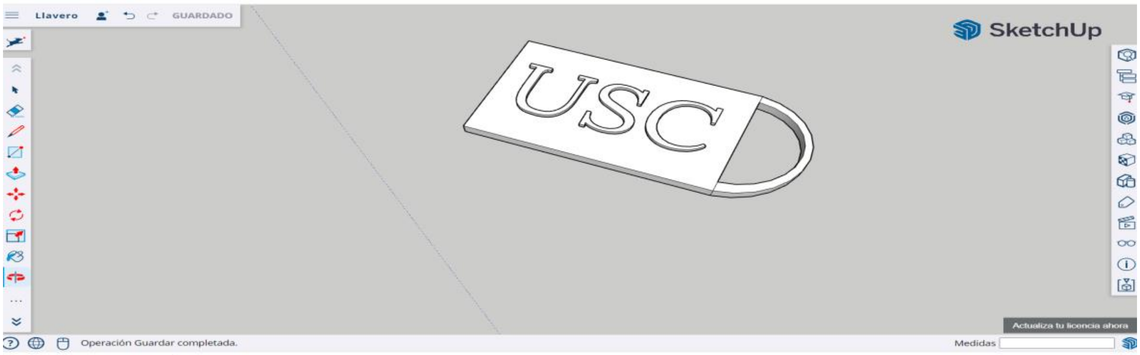
It's worth mentioning that the tool provides a multitude of design options, practically unlimited in terms of projects students can develop. However, this feature also constitutes a barrier to its use due to the necessity of explaining how each of the options it offers works (see Figure 7).

Figure 7. Sketch Up design options.



Lastly, SketchUp allows exporting and saving the design in multiple files to facilitate its use in other design tools and 3D printers (see Figure 8).

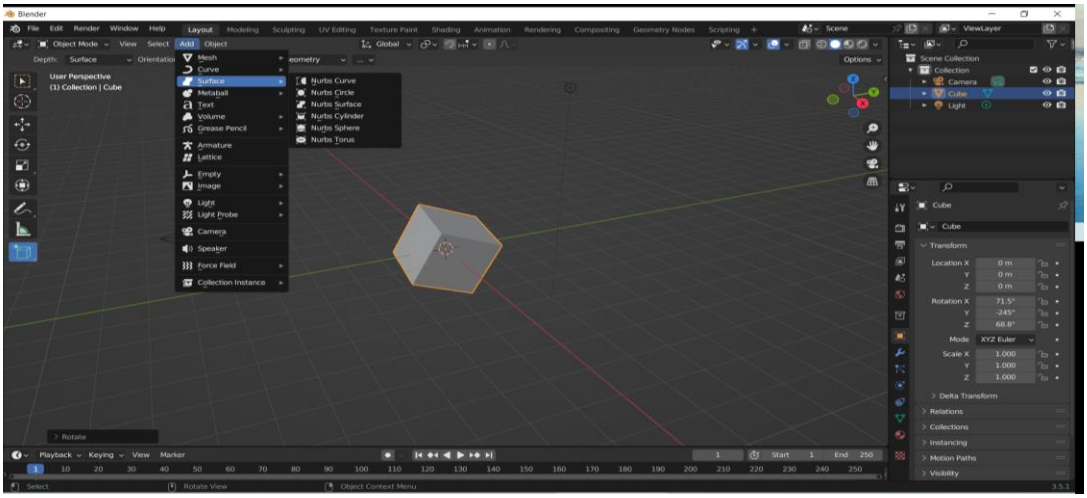
Figure 8. Final design of the keypad with Sketch Up.



Blender

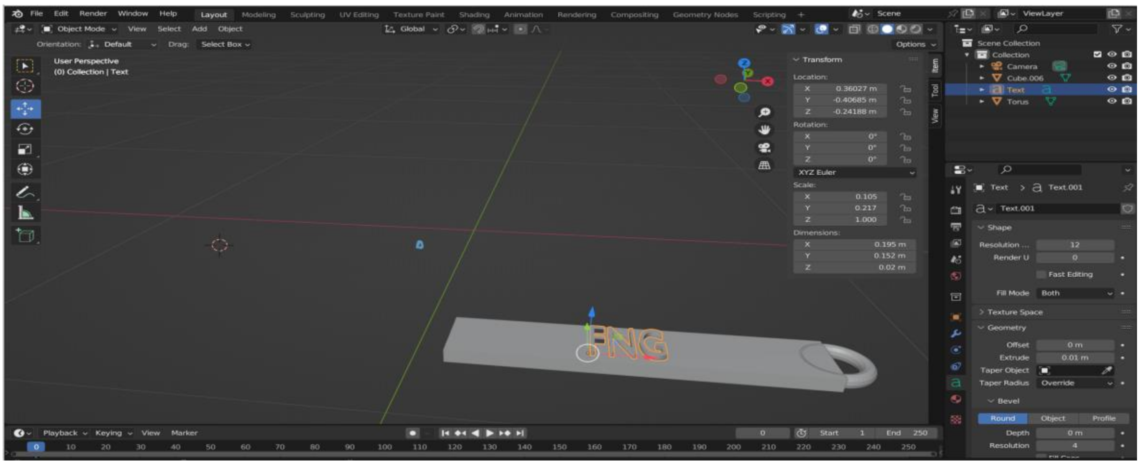
In contrast to the previous tools, Blender is a program that needs to be installed on computers, requiring higher technical resources. Regarding its functioning, it's a software with very high design capabilities that is offered for free. However, its operation can be very complex if the student is not accustomed to using animation and 3D design software. The creation and movement of objects are based on adding and selecting the appropriate mode (see Figure 9). Despite offering free help manuals and having access to multiple videos on platforms like YouTube, the learning period is lengthy and challenging.

Figure 9. Blender interface.



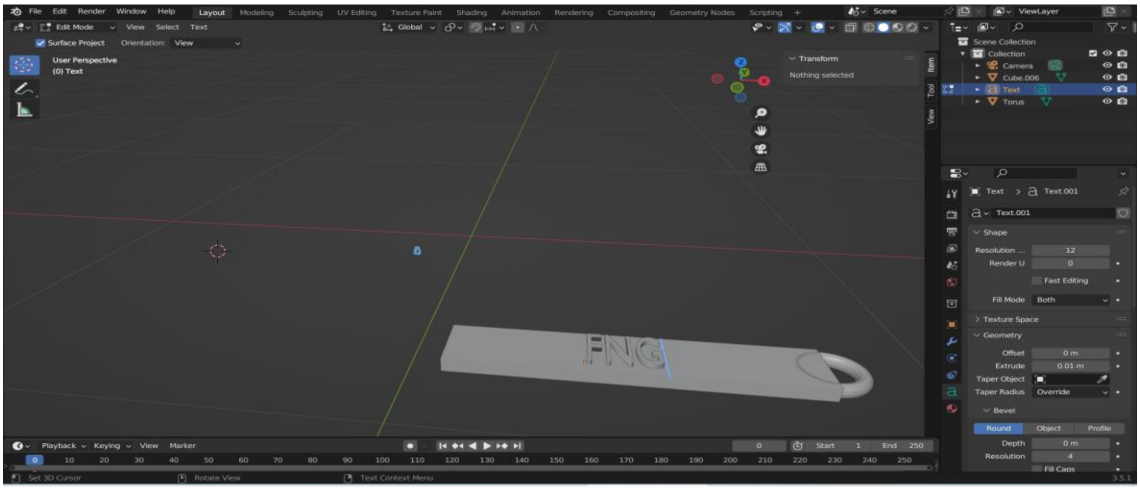
Once the basics functions and procedures are learned, one needs to become familiar with the use of commands. By selecting the transformation mode and pressing the N key, modifications in dimensions and object positioning, among other advanced options in the menu, can be made (see Figure 10).

Figure 10. Blender transformation menu.



However, objects like text must be modified through a change in Blender's mode. Therefore, it's also necessary to switch from Object Mode to Edit Mode to modify text content and other options. Once in Edit Mode, all necessary parameters can be modified to achieve the desired design (see Figure 11).

Figure 11. Final design of the keypad in the Blender.



DISCUSSION

The detailed analysis of the literature finds common ground among different platforms in the advantages of spatial thinking. The results indicate that spatial thinking, three-dimensional understanding, and 3D design abilities among students play a pivotal role in shaping society, supporting the findings of Taylor and Hutton (2013). Increased comprehension of spatial thinking during formative years enhances the likelihood of professional development (Stieff and Uttal, 2015). Hence, fostering skills and capabilities to visualize and create 3D models from 2D perspectives is highly pertinent (Liao, 2017). However, traditional educational methodologies cantered on theoretical concepts fail to meet the educational requisites in the domain of spatial thinking.

This issue has spurred interest among technicians and the educational community to develop new learning techniques based on the use of technology. According to the obtained results, 3D modelling and printing tools facilitate the acquisition of relevant technical skills and soft abilities (e.g., creativity, problem-solving, and autonomy) in a professional environment (Lobato and Sato, 2019). The findings from the analysed research reveal an overall enhancement in students' competencies through project execution (Trust and Maloy, 2017), problem-solving via innovative prototypes, and the design of replicas of everyday products (Lobato and Sato, 2019).

However, despite certain tools such as TinkerCAD or SketchUp offering didactic materials focused on users with little experience, the utilization of ICT tools demands significant effort during early stages (see Table 2). The experience gained through designing a keychain unveiled the necessity to develop programs that promote understanding the tool's functionality, as emphasized by Kelly (2014) in their research. Users, both educators and students, need a prior grasp of the basic operations of the tool and ICT to effectively engage in the targeted activities (Kostakis et al., 2015; Ford and Minshall, 2019).

Table 2. Comparison of the tools used in the design of the product

Tool	Advantages	Disadvantages
Geogebra	• Free tool • No need for installation (SaaS) • Possibility of rotating the figure • Design from simple figures • Employment instructions • Existence of a broad literature	• Design limitations in complex figures • Need for prior geometric formation • Figure export capacity
TinkerCAD	• Free tool • No need for installation (SaaS) • Design based on the union of previous figures • Possibility to include texts • Existence of a broad literature	• Design limitations in complex figures • Non-free design • Need for prior geometric formation • Figure export capacity • Limited employment instructions
Sketch Up	• Free tool • No need for installation (SaaS) • Specialized moi visual aspect • Intuitive to use • Multitude of design options • Existence of literature • Employment instructions	• Need for a broad prior geometric formation • Need for prior configuration of the tool • Default System: Anglo-Axon
Blender	• Free tool • No need for installation (SaaS) • Semi-professional design capability	• Need to install the tool • Consumption of many resources • Existence of reduced literature • Complex tool to use • Not thought of school didactics

On the other hand, 3D model printing allows self-verification of the work's outcome, complementing their spatial thinking skills. However, printing on household or educational machines has limitations that can lead to errors and frustration among students at the end of the process. Consequently, 3D printing might generate discomfort among students, teachers, and collaborators, discouraging its use (Buehler et al., 2016; Ford and Minshall, 2019). For this reason, it is crucial to employ tools aligned with the course level, considering the positive impact of spatial vision in highlighted areas of the marketing mix (Greenleaf and Raghubir, 2007; Goi, 2009).

CONCLUSIONS

Design tools, although usable at all educational stages, are not designed equally. GeoGebra is a tool conceived in its design, visualization, and mathematical supplements for early educational stages. Thanks to its design, inexperienced users can quickly learn to use it without the need for extensive geometry notions. On the contrary, SketchUp is a highly potent tool that could be used in advanced courses (in technical areas at universities) but is not recommended for early educational stages as it requires pre-existing design concepts. TinkerCAD, based on the combination of objects or shapes, allows the achievement of complex shapes and designs due to their combination. This feature enables students to understand that complex shapes result from combining simple geometric shapes and, therefore, that everything around us can be broken down. As for Blender, it's a powerful tool that needs to be installed, requiring greater capabilities of computer systems than those needed for basic 3D designs. Similarly, it requires a long and complex learning process that may discourage students.

Regarding theoretical implications, the conducted research demonstrates that any 3D design platform in the classroom offers numerous advantages but also challenges. At the same time, the results reveal the utility of combining a study of existing literature through SLT with the conduct of basic tests of the analysed concepts. Additionally, the study highlights the scarcity of research and a research gap. This circumstance is particularly noteworthy in the TinkerCAD and Geogebra platforms. In this regard, the study of these tools should be periodically updated to analyse potential evolutions in platforms and new educational software.

Regarding the practical implications of the research, the results show positive effects in educational terms under relevant conditions. Among these, the ability of teachers to understand the functioning, advantages, and limitations stands out. Thus, there is a highlighted need to train teaching staff to increase their willingness to use new technologies and 3D modelling and printing tools, which will be critical for the future society as a whole. Additionally, teachers should adapt educational programs to integrate new methodologies based on the use of design tools. Similarly, due to the need to learn how to use the ICT Platform, coordination between teachers and subjects is advisable to employ the same tools. Finally, it is important to select the tool based on students' prior knowledge and performance level to maximize educational benefits.

Moreover, it is recommended that public administration provide sufficient technological resources, computers, printers, and internet access to avoid restricting access to rural or less privileged areas.

Finally, it is important to emphasize that the methodology employed has limitations. Despite conducting tests of the analysed software with non-experts in design and studying the theoretical framework, the results may show divergence in the perception of adolescent students. In addition, the short number of the expert panel involved can conditioned the results due to their personal characteristics and abilities. Additionally, the research conducted has a high degree of theoretical analysis, recommending its completion through a comparative test involving marketing students. In addition, the manual process of SLR has associated possible delay in the research analysis and subjective perspective. Therefore, it is suggested to maintain the research line by using quantitative techniques to determine and verify the impact of the mentioned new technologies on pre-university and university students around the world.

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CRediT AUTHOR STATEMENT

The author has contributed equally to all parts of the work.