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3D Prototypes: Benefits for primary education and criteria for its implementation

Prototipado 3D: Beneficios para la educación primaria y criterios para su implementación

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Abstract
The following study intends to establish the key benefits of 3D prototype machines in technological education, along with a series of criteria for its incorporation at a primary level, determined by the analysis of technological concepts and relevant aspects of the educational area, in order to adequate its use into preexisting lesson plans. These criteria consider an appropriate level of cognitive development, and the influence of factors such as infrastructure, technical aspects, intended users, educational level, financing and cost.
key words: criteria for incorporation; 3d prototype machine; technological education; primary schools.

Resumen
El presente estudio busca establecer los beneficios primarios del prototipado 3D en la educación tecnológica, junto con una serie de criterios clave para su incorporación determinados a través del análisis de conceptos tecnológicos y de sus aspectos relevantes en el área educacional, para adecuar su uso en los planes de estudios existentes. Estos criterios consideran un nivel de desarrollo cognitivo apropiado y la influencia de factores como infraestructura, usuarios, nivel educacional, financiamiento y costos.
Palabras clave: criterios para incorporación; impresión 3d; educación tecnológica; escuelas primarias.

1. Introduction

Nowadays, humans are being bombarded by a great amount of technology from the moment we get up until we go to sleep. Internet, social media and devices such as smart phones, tablets and computers are part of the daily lives of people of all ages, but, above all, it is a great part of those called “digital natives”, those individuals that were born into a society that was already naturalized their digital environment, while those who were born before this naturalization are called “digital immigrants” (Jerez, 2013).

More recent generations tend to belong to the first category, though we must also recognize that there are also digital gaps given by geographical location and scarce economic resources that limit access to technology.

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Nonetheless, the world is being configurating rapidly through technology and many children are exposed to them at a young age. Thus, it becomes necessary to extend technological tools to classrooms, where they may acquire greater function and purpose. As researchers such as Moreno Martínez, López Meneses and Leiva Olivencia (2018) note, there must be a change in the pedagogy paradigm that responds to the demands of the society of knowledge and information and also to the characteristics of the student body of the new digital era, one that is defined by multitasking and must learn with new media through diverse sensorial means.

The search for effective technologies brings us to 3D Printing and the possibility of integrating this technology in schools to enhance learning processes in children that will rely on digital tools in their natural environment and will benefit, in cognitive as well as psychomotor aspects, by becoming familiar with them at a young age. Thus, we must consider that they are the primary users for which this type of technology must be adapted.

Before delving into the effect new technologies have had on the new generations, we must refer to another paradigm shift which has relocated linear thought to hypertextual thought (Cuadra, 2008). This new way of thinking is based on the intuitive association of multiple ideas, texts, and formats. With the appearance of new technologies, new ways of thinking are shaped, and this has a direct effect on the learning strategies of new generations. In so doing, we perceive a need to improve the quality of our education to respond to the massification and learning of new technological uses. By constating the development that 3D modalities will have in the world, we can bet that it will imply a fundamental contribution to the quality of education, worldwide, on levels as specific as three dimensional thought, design, modeling and comprehension of diverse matters through the creation of proper didactic material.

However, while auspicious, educational patterns call for caution as they appear to be fundamentally the same as they have always been. According to Marcelo Vera (2016), Director of Links of the Education and Technological Center of the Ministry of Education in Chile, “Schools must be renewed. We must bring our schools closer to the adolescent culture that is related to the use of technology. It is known that they have a greater access to smart phones and, therefore, to information. Thus, we must be able to move forward from teaching contents to teaching contents and skills” (Fundación Educar, 2016).

Hence, the Chilean minister of education emphasizes the importance of providing the necessary tools for students to carry themselves in the best way possible in today’s world, through diverse study programs. According to Sergio Balardini of FLASCO, Argentina (2003), it probable that, for the first time in the history of human society, the younger generations are teaching technology use to their elders. This implies that students of elementary and high school levels possess skills that previous generations did not have at their age. In light of this, we are faced with the following question: Are schools seizing the opportunity that new technological capacities of students have in an educational context? As a tentative answer, Marcelo Vera (2016) points out that, “Not only is it necessary to access technologies but to know how to perform in these new platforms, how to relate on collaborative networks and manage large amounts of information. It is a demand in today’s society since a great amount of young people who graduate from our schools today will work in occupations that do not yet exist or are still unknown. The required abilities will be different to those that adults need today (Fundación Educar 2016).

By recognizing the importance of the technologies of the future in children and young people, it becomes imperative that they be present in primary school programs, which bring us to our following question: What are the scopes and benefits that this type of technology can offer in technological education? What is the viability of the use of 3D printing in classrooms? How to incorporate the use of technology in study programs?

To begin answering these questions, we will carry out a recollection of data to better comprehend where the need comes from to integrate 3D printing into classroom lessons. We will question what are the benefits of activities related to 3D printing, first within an educational context, to explore in detail how new technologies are reconfigured as a tool for practical reinforcement for traditional learning styles and on what cognitive levels they should be applied; and secondly, focused on a technological context, in which we will develop the available resources for 3D printing to determine the criteria for the ideal technical specifications and needed infrastructure for its implementation in an educational space.

1.1. Education

In our society, the use and teachings of technology in education has placed itself on a core level for students to carry themselves in their environment. It is necessary to recognize that education today must establish a technological alphabetization. This, to understand the possibilities of 3D printing in classrooms, we will first focus on the importance of didactic material in classroom and on the levels of cognitive development, to identify the levels on which the planification of activities with digital technologies would be most appropriate.

1.2. The importance of didactic material in classrooms

The concept of didactic material can be understood from its own etymology, keeping in mind that "the term 'didactic' comes from the Greek *didastékene*, which means *Didas*, "to teach" and *Tékene* "art". It is, thus, literally, the art of teaching" (Castillo Beltrán, 2011). In this manner, didactic objects require a design process that can not be considered only on an aesthetic level but must be understood as an interdisciplinary work, in which design forms par of the entire process, from its configuration up until its function. For example, in the production of objects that have a didactic purpose, we must consider diverse disciplines such as learning theories, child development, psychology and art. In this context, Castillo Beltrán (2011) deducts that the role of the designer in production must keep in mind that, besides being entertaining, an object seeks to teach contents that must contribute to the enhancement of abilities and knowledge.

In accordance to this, the Universidad Nacional de México (National University of Mexico) establishes "Lineamientos metodológicos para la elaboración de material didáctico" [Methodological Guidelines for the Elaboration of Didactic Material], in which a didactic material is defined as an instrument that facilitates learning and teaching and is characterized by awakening the student's interest, adapting to his or her specific qualities and easing the teaching labor by accomodating contents to an experience that integrates new senses (UNAM). According to UNAM, all didactic material should possess the following characteristics:

- Awaken and capture the students' interest.
- Stimulate interaction during class.
- Explain abstract or complex concepts in a tangible way, not only through a screen or board.
- Allows for the observation of mechanical or physiological characteristics of diverse objects and organs.
- Consolidate previous knowledge.
- Favor the connection of previously acquired knowledge with new knowledge.
- Provide students with a variety of experiences that facilitate the application of their learning to real life situations.
- Promote creativity.

As these type of materials are directly related to learning, it is necessary to elaborate on the environment the materials will come into use depending on their goals, which will be defined by the phases of learning according to Marqués (2011):

1. **Access** to the information of the physical environment or that of other people from perceptive processes. In this case, we are referring to the information given by the didactic material-object.

2. **Process** of the information given using certain cognitive operative such as captivating, analyzing, elaborating, restructuring and synthesizing information, among others.
3. **Product obtained,** which can be the memorization of information or behavior, an acquired ability (psychomotor, cognitive, socio-emotional), understanding.
4. **Application** of said product by repetition or transference to new situations.

The elements of the characteristics that a didactic material must have, as much as the phases of learning that they must respond to, allow us to identify a series of criteria that must be engaged to ensure the quality of the didactic material-object elaborated through 3D printing that enhances child development. To aid in this process, we will briefly examine the foundations of cognitive development in young students hereunder.

1.3. Levels of Cognitive Development

Based on the cognitive theories of Piaget, Triglia (2015) affirms that there are four fundamental stages between birth and twelve years that consist on diverse biological and learning processes and allow us to understand certain aspects of our surroundings. For the specific purposes of this study, we will focus on the two last stages, corresponding to that of concrete operations, between seven and twelve years, and the stage of formal operations, placed at twelve years and onwards to identify in which way children in these stages can benefit from an education that implements technologies such as 3D printing in the classroom.

Concrete Operations Stage (7 to 12 years)

In this stage it is possible to use logic to arrive at conclusions, with the condition that the premise is based on concrete situations instead of abstract ones. Thought becomes complex, accepting new nuances and egocentric thought or that of the “Id” that is so present in previous stages begins to regress progressively. A clear indication of this stage is when an individual is capable of inferring that the amount of liquid contained in a container does not depend on the shape that the liquid acquires because it maintains its volume (Triglia, 2015).

Formal Operations Stage (12 years onwards)

From the twelf year and onwards, we can begin to see the last stage of cognitive development given by Piaget. In this phase, young people achieve the ability to arrive at abstract conclusions, without the previous requirement of premises depending on concrete statements. In this stage, and progressively forward, it is possible to deliberately analyze and manipulate schemes of thought and use reasoning that is hypothetical and deductive (Triglia, 2015).

In this sense, adolescence is marked by an accelerated development in cognitive and physical areas as much as social and emotional contexts. It is a favorable stage for students to advance with autonomy in an integral comprehension of the world that surrounds them. In this period, students move through processes that strengthen formal thought and allows then to establish logical relationships, develop critical thinking, understand abstract concepts, and connect conceptions that are apparently unalike (Alexander, 2006). Thus, it is an opportune stage to develop a more critical vision of the world and to reinforce their capacities for analysis, planification and hypothesis, which in turn, allows them to propose others problem solving methods.

Learning Styles

For the effects of this study, we will focus on a complementary line of cognitive development, from Pedagogy and Neuro-Linguistic Programming. This refers to the importance of perception features in students, such as the senses and the ways in which human beings relate to their environment through their senses to acquire significant learning.

In this theory, people are more sensitive to some senses than others. This means lessons can be more effective by assimilating diverse contents through these senses (visual, auditive, kinetic) over others. Studies about his phenomena have already been carried out successful on university students (Fernández & Beligoy, 2015) and there are great advances on students in primary education (Moreno, Molina & Chacón 2011), that could apply these models on students up to grade 8. According to Mosqueira (2012), there is a first characterization of students that synthesizes the approaches of Kolb (2007) in the following manner:

A student that learns better by combining concrete experience with reflexive observation has a **divergent** learning style.

A student that prefers to learn by combining reflexive observation with abstract conceptualization has an **assimilative** learning style.

A student who benefits by combining abstract conceptualization with active experimentation has a **convergent** learning style.

A student who learns best by combing active experimentation with concrete experience demonstrates an **accommodating** learning style.

There is also the possibility that some students have more than one learning style. With these elements, we arrive at a fundamental place in our student: There are characterizations within learning styles that come from the students' dominating senses. Díaz (2012) denominate this as "Student Characteristics According to the System of Dominant Sensorial Representation", which is shown in Table 1.

Table 1
Student Characteristics According to the System of Dominant Sensorial Representation

S of D. S Representation	**Characteristics**
Visual	They think with images. They speak and write quickly because they perceive that time in not enough to say and/or to write everything that is on their mind. They can think of many things simultaneously and not necessarily in a sequential order. They can do many things at the same time. They need to see, be seen and maintain eye contact with their interlocuters.
Auditive	Thought process is organized and sequential. They think of one idea and then move it to make room for the next idea. They speak slower than people with visual dominant sensorial representation. They carry out one thing at a time. To express themselves, they chose the adequate words that reflex with as much precision as possible what it is that they are thinking. They need to hear, be heard, and receive spoken feedback.
Kinetic	They involve themselves in what they do, despite environmental distractions. They like to participate with actions and opinions. They have an ease for perceiving their internal states, such as feelings and emotions. They think according to what they feel. They need and seek physical contact with others (pats on the back, hand shaking, hugs).

Note: Source material adapted from Díaz (2012)

Table 1 explains that human beings have dominant senses that can be understood as visual, auditive and kinetic; however, few aspects in the classroom integrate all these senses. Usually, the kinetic aspect is very subjugated to the other two senses. To respond to this shortcoming, 3D printing would enhance the visual aspect of concepts and materials along with the introduction of elements in third dimension to the learning context, in which students can touch and feel different textures, thus presenting an unexpected aspect within traditional learning styles and reinforcing the students' kinetic perception system.

2. Materials and method

3D printing is a process of rapid prototyping by additives, through which objects are materialized through CAD (Computer Aided Design) 3D models. In its beginnings, this technology was generated for the development of prototypes in industrial manufacturing to lessen costs and increase affordability. There are various systems of 3D printing. Their differences are found manly in the way their layers are created to construct a solid: Some methods use fusing or softening, and there are also other methods for liquid materials that are dried with different technologies and for which there are a great variety of materials.

Each method has its advantages and disadvantages. The aspects that we have determined of greater importance are: Printing Speed, Printing Cost (including materials) and Cost of Machine. Since 2003, we have observed a growth in 3D printer sales and their cost has decreased. This new form of manufacturing and materializing our ideas has already been implemented in diverse fields such as jewelry, crafts, food, fashion, industrial design, architecture, engineering, space industry, dental and medical. This has allowed for the creation of objects such as chocolate figurines, designer sunglasses and even houses on a Dutch canal (Buikstoler, Amsterdam), a two seat car (Strati, Local Motors, USA), the prototype of a bionic ear and many more. Smith (2014) highlights that big companies such as General Electric (GE), have already used 3D printing for the fabrication of fuel dispensers for jet engines and NASA is testing a 3D printer in the International Space Station, to vary food options, fabricate tools and spare parts on long missions. Smith (2014) interviews Hedwig Heinsman, one of the partners in the Dutch architectural firm DUS, who says, "I can see a time coming where you will be able to choose and download house plans like you were buying something on iTunes, customize them with a few clicks on the keyboard to get just exactly where you want, then have a printer brought onto your site and fabricate the house".

2.1. The importance of 3D printing in education

According to the OBS Business School Report (OBS, 2015), 3D Printing has been one of the technologies that has grown the most in the last years, estimating that between 2016 and 2021, there will be an increase of 30%. In the same manner, development projections for 3D modeling are also on track to increase in areas such as military industry (30%), architecture and industries related to the home (22%). Considering that the military industry is one of the world's biggest investors in Investigation and Development, just as the verified success of 3D printing in civilian matters, we can foresee a great projection in education in which this type of technology allows for the transformation of a digital and intangible design to a physical aspect through different aspects, each one in function of form and type of material used to create parts. In this matter, its possible to have, in just a few hours, tools, laboratory equipment, scale models and prototypes carried out by students themselves.

There are varied experiences across the world in which 3D Printing Systems have already been implemented. The incorporation of this technology has taken place mainly in universities and other institutions of higher learning and it has gained more and more space and experts with the generation of prototypes, scale models, reproductions of art masterpieces, of bone structures, medical, biological and historic pieces, among others. This allows students to have another perspective of their contents, visualizing and interacting with elements that only could find in books or multimedia material.

According to José Luis Camaüer, associate founder of Kikai Labs, leading Argentinian business in 3D printing of prototypes, "The benefits are enormous, given that it is a tool that allows students to create physical objects without great cost or dangers of the material cutting machines. Printed plastic artefacts can also be combined with electronic and mechanic parts. It provides an optimal activity for group work and it involves different abilities and knowledge in playful projects” (Camaüer 2014).

Nowadays, based on investigations on the debate for educational quality in Chile (Gaete and Ayala 2015), education doesn’t adapt to the new experiences and ways in which students in primary education learn, nor does it uphold the expectations that the general public has. In an investigation carried out by Silva Pena (2016), we can identify the following problem in the technological context: The vast access that children and young people have to diverse sources of information in their home, which allows them to learn new technologies rapidly, is not reflected in the normal teaching process of municipal establishments.

2.2. 3D printing systems and software

Rapid additive prototyping, commonly referred to as 3D Printing, consists on a group of automatic manufacturing systems that use CAD 3D data to build three dimensional parts by layers without the need of other tools.

In order to carry out the printing, it is first needed to convert the CAD 3D file to STL format, which is the extension of the additive prototype machine controller software. Once converted to this format, the model is divided into many thin horizontal layers which will then be interpreted by the printer software so that the printing process can begin.

2.2.1. 3D printing systems

For the specific purposes of this research, we must only consider systems that will be feasible in the context of a school classroom for which we will limit this section to additive prototype systems only, based on monograms developed by Bryden (2014).

Stereo Lithography apparatus (SLA): This machine was designed by Chuck Hull in 1986. It was fabricated and commercialized by 3D System as the first rapid additive prototype available in the market. In the first process of Stereo Lithography (SL), the piece is constructed on a perforated platform, located horizontally in a container of liquid resin, which solidifies when exposed to ultraviolet (UV) light.

At the beginning, the platform is located at the superior part of a tank and descends according to the distance configurated on the machine and a mechanical arm sweeps a layer of liquid resin, activating the laser. In this manner, the platform continues to lower and solidify layer after layer until the desired piece is complete. The thickness of the layers varies between 0,05mm and 0,15 mm depending on the ASL being used and the adjustments established by the user.

Polyjet: This ink injection system, introduced to the market by Objet, utilized photocurable liquid resins, just like stereo lithography but, in this case, the printing material as well as the suction material are deposited by printer heads and solidifies by a UV lamp. The printer heads deposit the material only where it is needed, with which the piece is fabricated from the ground up.

This system works with more than one hundred different materials which allows for the creation of pieces that combine hard, soft, transparent and opaque materials in a variety of colors. Pressure varies between 1,02 mm and 0, 08 mm and fine layers can be was thin as 0,016 mm and as thick as 0,6 mm. The suction material is dried forming a sort of jelly that can be washed off with a stream of water or by hand.

Digital Light Processing System (DLP): This technology, developed by Texas Instrument, was developed in 1987. It utilized photocurable resins to create parts and pieces but, unlike the SLA system, DLP curates volumetric pixels (voxels), using mirrors to reflect UV light on the points that correspond to a very thin layer of resin. The piece is constructed face up so that the platform remains above while the part is suspended below. The suction material holds the piece to the platform and to the geometries protruding from the model.

The thickness of the layer, which is equivalent to the height of the voxels, can reach up to 0, 015 mm, which is the pieces do not seem graduated and allow for exact replicas of small and complex parts. For closed volumes, we must consider that CAD models have an opening for the resin to exit without drying or pooling.

Selective Laser Sintering (SLS): The Selective Laser Sintering System uses a laser to sinter thermoplastic powder, like nylon or polyamide by heating the powder to just below its point of fusion and facilitate the action of the laser in a process previous to the fabrication of the part. In SLS, the piece or part is formed in a chamber over a descending platform. Each time the platform descends, powdered resin in applied and later melted by a laser light. When the laser melts a layer of the material, it unites with the previous layer and the process repeats itself until the piece is finished. The thickness of the layers can be between 0, 05 mm and 0, 2 mm and the thickness of the walls can be of up to 0,7 mm. The biggest SLS machine can elaborate piece of up to 700 mm x 380 mm x 600 mm.

Direct Metal Laser Sintering (DMLS): This technology was developed by EOS in the nineties. Its printing process is very similar to SLS but, in this case, the pieces are elaborated from metallic powder. A thin layer of powder is dusted from a container over the platform that is found within a construction chamber. A CO2 laser then melts the corresponding section to every laminate of the model at high speed. This process repeats until the piece is finished, generating a suction structure at the same time, which is removed once the piece is concluded. Nowadays, this system is used for the elaboration of special pieces for the space industry, sport engines and the medical and dental fields, among others. The most common size of the fabrication chamber is of 250 mm x 250 mm x 250 mm, although there are some that measure up to 500 mm x 500 mm x 500 mm. The thickness of the layer can vary from 0,02 mm to 0,1 mm.

Tridimensional Printing (I3D): Developed by MIT researchers from the beginning to mid-nineties, tridimensional printing uses ink injection technology to generate pieces by depositing a binding agent over fine layers of corn starch, plaster, or polymer powder. Once the layer has unified, the base lowers and a roller extends a new layer of dust over the previous one and the process repeats. The maximum size of the pieces is of 508 mm x 381 mm x 229 mm and the walls can vary from 0,5 mm to 1 mm while the parts of the model that support its weight can vary between 2 mm and 3 mm.

Fused Deposition Modeling (FDM): Developed in 1988 by Scott Crump, this is one of the most popular systems. The thermoplastic filament is heated over its fusion point and is extruded by a printer head, which deposits over the corresponding transversal section until the piece is finished. Among the most common plastic materials used are: ABS, PLA and FilaFlex. The material selection depends exclusively on the use for which the piece is intended. The minimum thickness of the wall of the pieces is 0, 5 mm and the maximum size for the pieces in the bigger machines are 600 mm x 500 mm and 600 mm.

Once exposed to the different printing systems, we must consider that this machinery will be situated in a school, where it will be installed in an office or classroom. We must also consider that the machinery, as well as the fabricating materials, will be in contact with students and it is necessary to limit the machines to these parameters as Table 2 shows.

Table 2
Comparative Table of printing systems according to workspace, accessibility and supply management, and printing time

Printing System	Workspace	Accessibility and Supply Management	Printing Time
SLA	Feasible	Feasible	Not Feasible
Polyjet	Feasible	Feasible	Not Feasible
DLP	Feasible	Feasible	Not Feasible
SLS	Feasible	Not Feasible	Not Feasible
DMLS	Feasible	Not Feasible	Not Feasible
I3D	Feasible	Not Feasible	Not Feasible
FDM	Feasible	Feasible	Not Feasible

Note: Source material adapted from Bryden (2014)

2.2.2. Software

For the materialization of objects through 3D Printing, there must be a digital model of the piece. This is achieved through at least on program or application of 3D modeling. This type of program belongs to a group of software denominated CAD, which are generally commercial but can also be found free in online versions.

CAD – Computer Assisted Design: CAD consists on the use of special computerized programs to create graphic representation of objects which can be two dimensional drawings or three-dimensional virtual models. It is widely used in computer animation and special effect in movies, advertising and products of different industries, where the software carries out the necessary calculations to generate the shape and size for a variety of products and applications in Industrial Design, Engineering, Architecture and Medicine, among others.

In the case of Industrial Design and products, CAD is used primarily for the creation of surface or solid 3D models, for the visualization and fabrication of models and, also, for drawings of physical components based on two-dimensional vectors. Table 3 represents some of the most used programs that are hereafter explained.

Free Software: A software is considered free when it allows certain liberties to the user over the acquired product. According to GNU: “Broadly, it means that users have the freedom to execute, copy, distribute, study, modify and improve the software” (2016). However, this does not mean that it is necessarily free of charge. Some examples of free software that are free of charge are:

Blender 3D: It is one of the most known tools for modeling, manipulation, animation, simulation, rendering, composition and following movement, video editing and game creation.

K-3D: This tool is always well known as to 3D modeling, animation and rendering. Among its main features, it is easy to use and is considered ideal for beginners for its great potential for design that allows for the creation of the simplest models to complex and professional projects.

Wings 3D: 3D modeling tool, it has a completely configurable interface, a great number of tools to facilitate the design of elements and is also compatible with practically any other 3D designs.

Thingiverse: This platform is an online community in which registered users create and share their 3D designs, accompanied by descriptions in which they explain and detail the materials and techniques utilized and the finality for the constructed object, The models are grouped into categories of art models, fashion and tools. Also, it counts with a special section for the area of education, where models can be found for different subjects and ages.

Tinkercad: It is a simple design tool for 3D modeling based on a navigator that everyone can use. It allows users to design whatever they require in little time. The user does not need previous CAD knowledge to create and print 3D models. The models that are created with this application are stored in a cloud, needing only of an internet connection to access them from any place and there is no hardware required for the storage of the models. This web application uses construction blocks of basic shapes for the construction of models which can be used in any form to add or remove material, as well as to import and create personalized shapes. New models can also be generated by grouping together shapes to constrict complex forms with a high level of detail, as well as shapes from imported 2d vectorial shapes to extrude them and form editable tindercad blocks.

Additionally, their web page has a section orientated towards teachers where they must

- Create an account
- Log in
- Generate an invitation code in the Education page
- Share with students

In this manner, the integration of this type of program can be facilitated since there is no previous knowledge of 3D modeling required for good results. It simplifies the labor of the teacher as much as that of the student.

Finally, there must be a revision of the software that controls the printing system.

Machine controller software: The last step in printing an object in a 3D printer, there must be a controller software to configure the printer and establish the pertinent adjustments to obtain the desired result. Nowadays, we can find several program options to control a 3D printer and advance the model from extension .stl to gcode format s3g or x3g. This format will indicate the route and specifications necessary to carry out the printing of the piece. In some cases, this software comes along with the printer at the time of purchase. In other cases, there is a variety of this type of program available on line, which are mainly free and open source. They generally possess a graphic interface that is easy to use. Some examples of this controller software are:

- Replicatorg
- Makerbot Makerware
- Repetier-Host
- Cura

3. Results

Following the previous analysis based on the technical specifications of the 3D printing systems, and considering the type of user, software and workspace of an average classroom or office in a typical primary school in Chile, the recollected data advises towards the Fused Deposition Modeling (FDM) as the ideal system for these parameters. This system adjusts the best to the workspaces that are presented in schools and for users that are mainly students and teachers. We must consider that, in an initial phase, a professional preferably from a technical area of design should train the teachers in charge of technological workshops.

The use of this printing machine in particular is less complex than others. This allows a person without great technical knowledge to operate it. Also, in terms of school safety, we can argue that among the materials used, we can count on PLA and Filaflex, which do not produce toxic gases while melting.

As to the most ideal grade levels for the implementation of Technological Education, we can determine that children around the age of twelve are the most prepared as they are situated in a stage of cognitive development that allows them to perceive volume (Concrete Operations Stage) and are on the brink of the following stage, in they which they achieve the comprehension of abstract concepts (Formal Operations Stage). This would allow them to develop and encourage the necessary capacity to grasp volume in 3D design.

Pertaining to Learning Styles, we can infer that, through the use of 3D technology, we can promote three common aspects of the characterization of students: Concrete Experience, Reflexive Observation and Active Experimentation. To this, 3D printing adds to the already exploited visual modality of a classroom, a kinetic modality for the achievement of significant and lasting learning, which justifies wholly the use of 3D printing as didactic material for the activities in a Curricular Program of the subject of Technology in schools, considering both the modeling process and the product of 3D printing.

As to factors such as necessary space and work conditions, we must consider rooms such as offices or classrooms that can be used as workshops, with substantial natural light and evenly distributed artificial light in which large desktops, computers and electrical outlets can be places to connect the printing system and computer equipment.

There is no need for special electrical installation for the use of the Fused Deposition Modeling (FDM) System, as its energy consumption is similar to that of a portable laptop and most educational institutions already have a computer room or laboratory with an efficient electrical installation.

Regarding the necessary software and the level of knowledge required to operate the printing system, we must highlight that there is only a basic level of training required and though there are numerous professional modeling programs available, schools should only work with platforms and web applications intended for beginners so that teachers and students alike can initiate themselves in this area.

4. Conclusions

Throughout this paper, we have exposed several printing systems and the pertinent software that corresponds to 3D printing. We explored the new paradigm that educational professionals and institutions face, in which the process of digital technologies and their influence shape the daily lives of children worldwide. Given today's generation of digital natives and the broad scope of technology, it is imperative that we recognize the importance of didactic material in classroom meets the expectations of the digital environment in which society is evolving. In this study, we have analyzed levels of cognition and learning styles that determine the best way in which to implement digital knowledge in education and have determined that it is necessary to make the technological knowledge that young people have access to in their homes a practical tool in schools.

Regarding the most ideal levels for the implementation of Educational Technology of boys and girls, we propose that they must be around twelve years of age in order to find themselves in a stage of cognitive development that allows for the perception of volume (Concrete Operations Stage) while at the beginning of the following stage in which they achieve a comprehension of abstract concepts (Formal Operations Stage). This will allow for the development and encouragement of the necessary capacity for them to grasp volume and 3D Design.

Concerning learning styles, we can also infer that, by using 3D technology, the three aspects common aspects of student characterization can come together in one lesson. This would include Concrete Experience, Reflexive Observation and Active Experimentation. To this we can also add that 3D printing will bring a new aspect of kinetic modality to the more commonly used visual modality in classrooms and will promote more significant and lasting learning processes. Thus, 3D modeling and printing processes and results must be considered as didactic material within the Curricular Programs in technology classes in primary schools.

In this study, we have determined that the best printing system for a classroom or office inside a primary school is Fused Deposition Modeling (FDM) System and, for the safety of students and teachers alike, the best materials to be used for printing are PLA and Filaflex because they do not produce toxic gases when melting.

This type of research is extremely important given that there are fundamental barriers regarding the integration of this technology mainly due to lack of information in teachers. It is crucial to address the fear of technology and tear down the myths that make technology and digital tools seems difficult to manipulate or hard to access. It is time to bring technology closer to students and meet the necessities of globalization and the younger generations that respond to them.

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