International Research Journal of Management, IT & Social Sciences
Available online at https://sloap.org/journals/index.php/irjmis/
Vol. 7 No. 4, July 2020, pages: 1-8
ISSN: 2395-7492
https://doi.org/10.21744/irjmis.v7n4.935

Maker Movement: Strategy for the Construction of Knowledge in High School Students

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Article history:

Submitted: 27 April 2020
Revised: 18 May 2020
Accepted: 01 June 2020

Keywords:

collaborative learning;
maker;
social movements;
teaching-learning;
technology innovation;

Abstract

The objective of this work is to identify the characteristics of the Maker movement that facilitate its use as a teaching-learning strategy for the construction of knowledge in high school students. This research was carried out using the desk research methodology, based on evidence from previous application studies of the Maker Movement for the training and motivation of high school students. The Maker philosophy has fostered a new environment for learning based on the theory of constructivism, whose main characteristic is the involvement of students in the creation of artifacts that serve as conductive threads for a series of processes to be carried out that involve cooperation, collaboration and lifelong learning, underpinning processes of experimentation and exploration, in which all phases of the scientific method must be covered, requiring the use of interdisciplinary knowledge, always in a supportive environment. The Maker movement is a catalyst, which promotes learning, with a high dose of motivation, increasing student performance. In Ecuador, mechanisms have been established to promote this culture through the installation and growth of FabLab, in addition to having an increased activity of maker movements in educational institutes.

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1 Introduction

In the post-war years, after the Second World War, a movement was established in the United States, called Do It Yourself, to the extent that Technologies evolved, making it affordable for many, in economic terms and because of learning, from there a current has been generated, which has been called "Movement Maker". It includes a valid strategy for the production of knowledge, in which a transformation is fostered through collaborative activities that include supporting, sharing, and learning (Pérez, *et al.*, 2020).

It is possible to predict, in this digital and autonomous learning era, the importance that the Maker culture can have to motivate young people to develop and strengthen capacities, abilities, and skills in the management of digital technology, for the construction of "artifacts" (Sanabria, 2018), as indicated by Seymour Papert, father of this movement, learning is closely associated with the elaboration of artifacts, stimulating an activating process for the construction of knowledge (Vossoughi & Bevan, 2014). The Maker culture has as its main engine a playful strategy, in which the participant plays with technology to learn from it, this type of practice fosters a positive attitude around the acquisition of knowledge, hinting at free choice activity, such as Participant takes responsibility and chooses his learning path, in which failure is valued as a resource, and is attributed a positive value (failing is the new winning). Giving a new vision of failure in a creative experience (Tesconi, 2018).

The Maker Movement is considered a social movement, so the apprentices feel part of a scientific community, involving them collaboratively to generate and share knowledge, this constitutes a motivating element, increasing the feeling of achievement through useful achievements materialized in devices with a high technological content (Martínez, 2016; Şener & Sarıdoğan, 2011; Ferneley & Bell, 2006). Maker Movement is understood as the international phenomenon, which focuses its importance on what is done, how it is done, where it is done and who does it, as a social revolution that drives human beings to be transformers of the world, using the tools of the internet and the affordability of technological devices such as sensors, 3D printers, and Arduino devices, among others, which is possible through collaborative learning, so it represents a counter-cultural phenomenon, inviting people to come together to solve problems (Dougherty, 2016; Gonz ález *et al.*, 2018; Handayani *et al.*, 2019; Laal & Ghodsi, 2012; Van Boxtel *et al.*, 2000).

This type of process must be faced due to the era of interconnectivity, in which innovating is due to prototyping the future, so from high school education knowledge must be generated so that the task of innovation is a constant task, as part of any exercise (Martínez, 2016). In general terms, the student at the baccalaureate level has little experience in managing technology aimed at the construction of devices that solve problems, using digital equipment and tools, such as 3D printers and Arduinos development cards, being activities with a high motivational value for young people. So the objective of this research is to identify the characteristics that the Maker Movement presents that facilitate its use as a teaching-learning strategy for the construction of knowledge in high school students (Chamoso *et al.*, 2012; Rao *et al.*, 2012).

2 Materials and Methods

Starting from the defined objective, the type of research to be carried out has been evaluated, considering that it is framed in a type of qualitative research, using the evidence-based research approach, in the field of the maker movement and its applications in the teaching-learning processes at the high school level. This type of selected research technique allows the creation of knowledge-based on publications made in previous studies (Revelo-Sánchez *et al.*, 2018).

This technique contemplates a series of steps including: a) planning of the criteria for inclusion, extraction, and synthesis of documents found, considering the quality of the databases to be selected, b) search using as criteria the keywords defined in the research, c) preliminary selection of suitable articles, d) evaluation of the quality of the Article according to context and search criteria (fundamentally, last 5 years), extraction of synthesis of the most relevant data found and metadata and e) subsequent reporting of results (Revelo-Sánchez *et al.*, 2018).

3 Results and Discussions

The results of this research started from the proposed objective, which consisted of characterizing how maker philosophy can support the learning process in the technological area for high school students. In this sense, a review of different databases was carried out, in which Redalyc, ScienceDirect (Scopus), Google Scholar were considered, finding distribution in the number of publications per year, from 2010 to 2019, as shown Figure 1 shows the increase in articles published about the term "Maker Movement", both locally and globally, showing a growing increase in them, showing increasing interest in the subject.

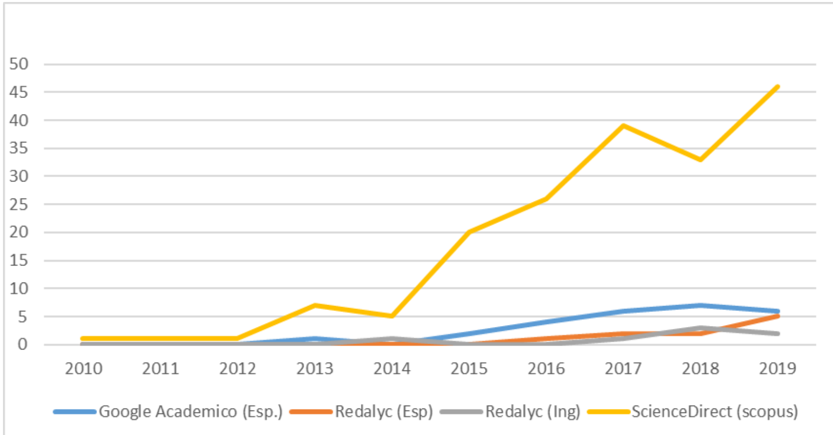

Figure 1. Publications with the term Maker Movement

Currently, the teaching-learning process responds to new paradigms, leading to the constructivist approach, where the student is placed as the protagonist, promoting strategies to develop concepts and structure their knowledge. In this way, the need arises to interconnect aspects of a theoretical nature and practical experiences, to allow assimilation through the manipulation and exploration of objects and ideas (Gonzalez *et al.*, 2017).

Within the educational processes, the use of ICTs has been strongly incorporated, this fact has been favored by the inherent culture of today's youth, which makes them prone to the use of technology as a natural element of training and playful experiences, besides of being naturally familiar with its use, this has generated new virtual spaces creating educational scenarios, which has allowed to change, in a positive way, the dynamics between teachers and students, facilitating the development of skills, increasing motivation, promoting social ties, among other relevant aspects (García *et al.*, 2007; Rao *et al.*, 2000; McFarlane, 2009).

The strategy is to develop structured thinking in students, which allows them to move towards the development of more logical and formal thoughts, so they must provide tools that promote the transformation of concrete experiences, towards the generation of abstract ideas, where students learn to handle simultaneous variables that intervene in the various phenomena proposed for their simulation, understanding that it is necessary to simultaneously have a scientific-technological conceptual base, in which it is possible to go from induction to deduction, integrating disciplines to achieve a project (Ruiz-Velasco, 2007). Technological learning can be based on the aspects indicated in constructivism, in which the student is an active participant in his training, and for which, he must solve concrete problems, contextualized with real value. Technological learning focuses on developing exploration and experimentation for the interpretation of results, trajectory, and execution of the scientific process, so the design and development of technological prototypes serve as a pretext to motivate learning collaboratively, regarding different topics and concepts from different areas of knowledge (Ruiz-Velasco, 2007).

This type of technological learning makes it possible to link different hypotheses, integrate them, generate discussions from them, corroborate, err and repeat, multiple times the steps in the experimentation of the scientific method. The simultaneity of acting between a specific exercise or handling of real-life phenomena, together with useful technological resources in the market, allows them to start in the approach to the study of science and technology, understanding these as holistic, holistic disciplines, systematic, which merit different areas of knowledge. The Maker Movement has been present, significantly in the last ten years, some statistical data confirms it, more than 400 maker manufacturer fairs have been held in the last 8 years, in the New York area, just in the “Maker Faires” fairs, from 2014, attended by around 215,000 people, The most common technologies in the Maker field, such as embedded systems (Arduinos technology or similar), Kickstarter, 3D Printers, will exceed 10,000 million dollars by 2020, evidencing an important market (Salamanca, 2020), has also come to foster interaction between young people, channeling their desire to experiment with technology (Núñez & Hepp, 2018). Maker movements are developed under the theoretical and pedagogical pillars, resulting from constructivism, such as experimental education and critical pedagogy (Tesconi &

Arias, 2015), powered by technological development and interaction routines between students and technologies, this interaction is shown schematically in figure 2. The laboratories for these learning have expanded and diversified and are known as Maker Spaces (Núñez & Hepp, 2018; Ramos *et al.*, 2017).

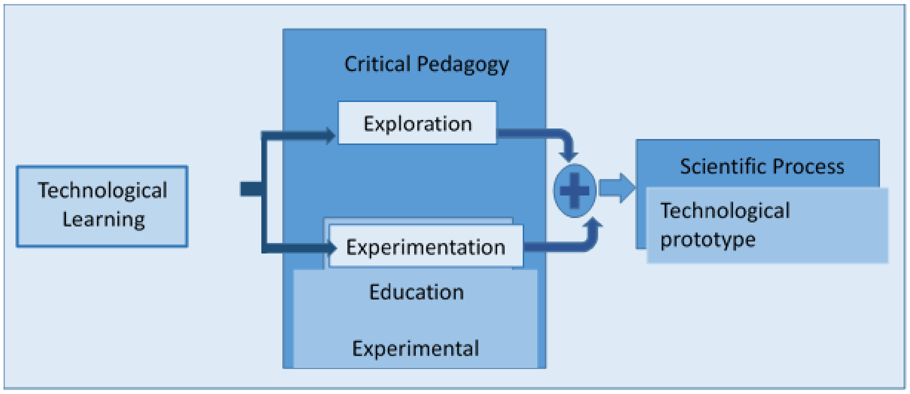

Figure 2. Technological learning from the Maker philosophy Maker

In philosophy, the interaction between its members is important, so it is considered an integration environment, stimulator of creative work, as explained by Martínez (2016), in this type The Maker philosophy (Gutiérrez, 2018) is developed on stage, which has been characterized as shown in Table 1.

Table 1
Characteristics of the Maker philosophy (Martínez Torán, 2016)

Characteristic	Description
Creation	It is the design and manufacture of devices based on individual or collective ideas
Cooperation	Knowledge and skills are shared within the community
Collaboration	Intellectual property is presented to the community of work
Learning	meaningful learning "LearningDoing", based on theoretical knowledge
Equipment	tools, hardware and free software, 3D printers
Participation	collaborative work growing base so continuous, sustained in communities, events, sharing common interests
Support	The support I financial, Individual and collective, in addition to the collaboration of private and public entities,
Game	Stimulation for creativity in recreational spaces where work and play are intertwined
Change	Positive emotion, knowledge, and skills to promote motivation

There are numerous projects in the world With the Maker philosophy, within which the factory laboratories (FabLab) stand out, an idea developed at the Center for Bits and Atoms (CBA) of the Massachusetts Institute of Technology (MIT), the strategy gravitates on the relationship between the content of the information and its physical representation, and the empowerment that they provide to the communities, through the use of base technology. There are more than 1750 Fablab worldwide, in the specific case of Ecuador, there are 11 FabLab, of which 5 are in operation and 6 are in planning, their location is shown in Figure 3 (Foundation, 2020; Ropin *et al.*, 2020).

The current trends of maker spaces dedicated exclusively to education are known as MakerED, among the elements that make them up and their interaction is shown in

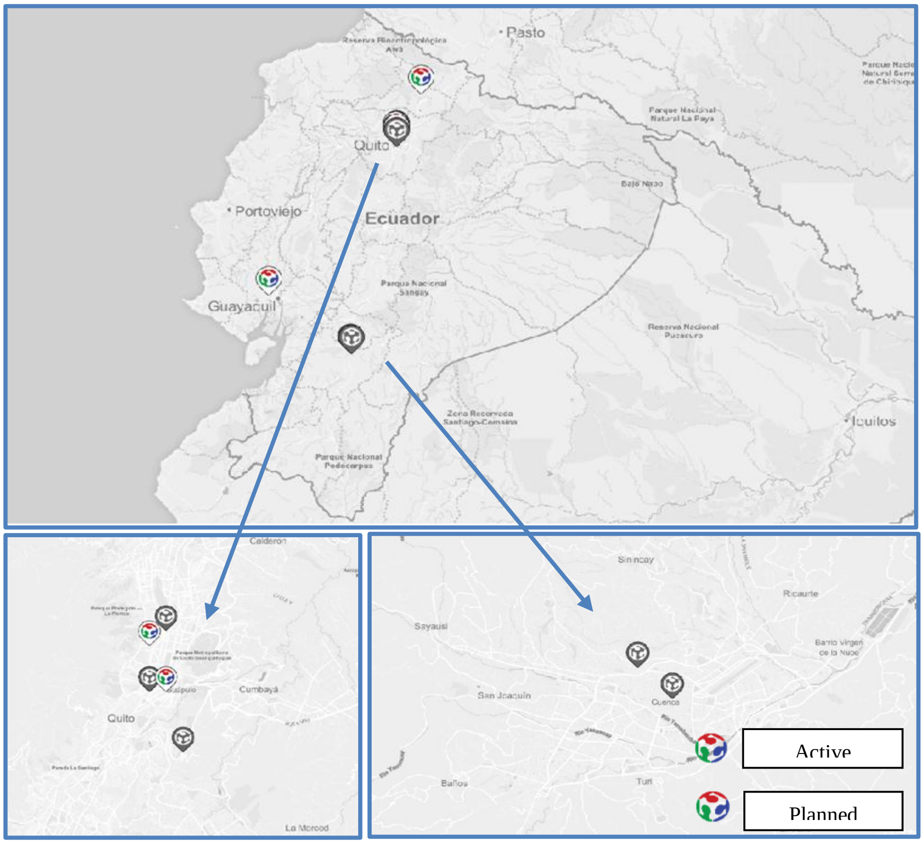

Figure 3. FabLab projects in Ecuador (Foundation, 2020)

Figure 4, they are based on the need that students understand that they can appropriate this philosophy as a training tool, for learning to create technology-based companies, for access to professional practices in science, engineering, technology, and design, as educational practices oriented to inquiry and as an interdisciplinary bridge, so these spaces allow professional and cross-disciplinary training for the exchange of knowledge and project development (Vossoughi & Bevan, 2014).

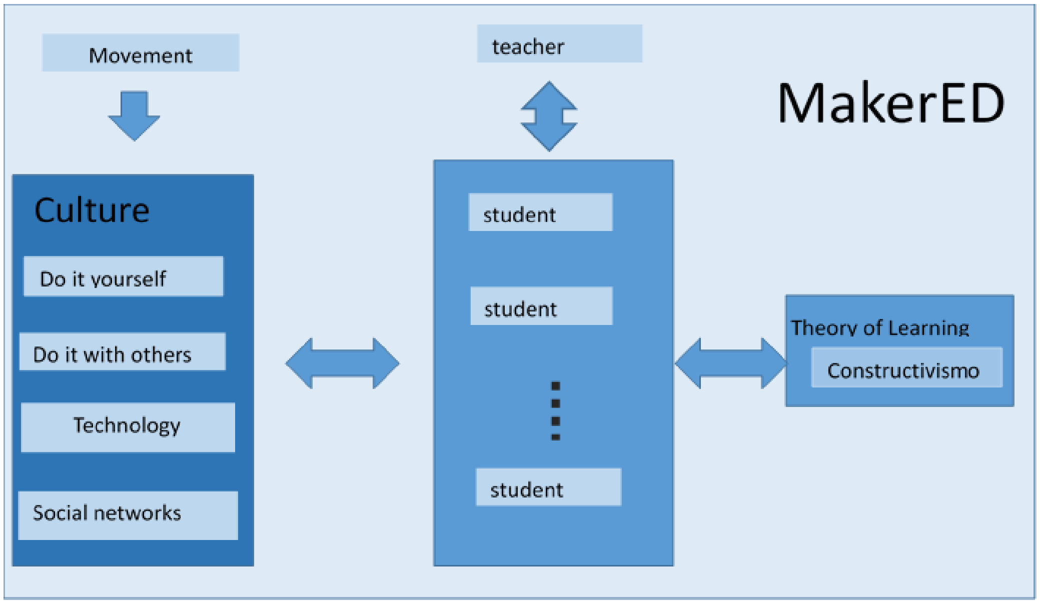

Figure 4. Components of MakerED spaces

Within the Maker philosophy, a form of joint learning teaching has been developed where the disciplines of science, technology, engineering, and mathematics come together, which together has generated an area of knowledge known as STEM education (acronym in English). Science, Technology, Engineering, and Mathematics), is an educational, interdisciplinary, practical, and applied trend, which is based on the relevance of science for technological learning (Arredondo *et al.*, 2019).

The way how in an integrated way the different areas of knowledge complement each other for the explicit assimilation of useful concepts from two or more of these disciplines (Fuentes & González, 2019). For example, the engineering approach is developed in the theoretical knowledge required for the design, incorporating constructive elements for the realization of the prototypes, this concretion of the idea, materialized in the device, is of high educational and motivating value, promoting young people the desire to continue the process (Ludeña, 2019; Martini & Chiarella, 2017; Pérez-Rodríguez *et al.*, 2020; Rodriguez Borges *et al.*, 2020).

4 Conclusion

The Maker philosophy has fostered a new environment for learning based on constructivism, with the characteristics of creation, cooperation, collaboration, learning, support, as well as planting constant change. The natural condition towards the technology of young people in high school education ages makes the Maker movement a catalyst that promotes learning, with a high dose of motivation, increasing student performance, the results are projected into the future as a valid strategy to complement education at that stage. In Ecuador, mechanisms have been established to promote this culture through the installation and growth of FabLab, in addition to increasing activity in educational institutes.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

Acknowledgments
We are grateful to two anonymous reviewers for their valuable comments on the earlier version of this paper.

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