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MAKER EDUCATION: FROM ANCIENT GREECE TO CONTEMPORARY BRAZIL

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Fernando José de Almeida[1], Tatiana Sansone Soster[2] and Maria da Graça Moreira da Silva[3].

ABSTRACT

The article reflects on the evolution of the maker movement in the Brazilian educational context, tracing its roots and educational, philosophical and historical concepts, connecting them to current practices. With a qualitative approach, it presents an essay and case study through the analysis of the project "The City We Want". It also explores how the different principles of the authors are applied in contemporary maker education. While highlighting the significant contributions of these approaches to the democratization of learning and the development of critical skills, the study also recognizes challenges to be overcome, such as financial sustainability and the specific and complex teacher training required. From a critical analysis, ways for an effective and inclusive implementation of maker practices in Brazilian schools are suggested, highlighting the need for curricular public policies and support for conditions and continuous training of educators.

Keywords: Maker Education, Digital Inclusion, Learning by doing, Social learning, Curriculum.

[1] Doctor of Education
PUC São Paulo
Email: Fernandoalmeida43@gmail.com
Orcid: 0000-0002-6498-3427/
Lattes ID: 0130775836783181
[2] Dr. in Education
FGV Brasilia
E-mail: tatiana.soster@gmail.com
Orcid: 0000-0002-7120-6853
Lattes ID: 6862777143370867
[3] Dr. in Education
PUC São Paulo
E-mail: mgmoreira@pucsp.br
Orcid: 0000-0002-4798-9122
Lattes ID: 7868517261081624

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INTRODUCTION

There is nothing like a good historical step back to see how the fluctuations of pedagogical awareness need not be so many. History is abundant in showing that education tends to move in a progressive direction. The reactions exist and are persistent. Elitization, exclusion, segregation, deception, false prophecies are disguised as disruption and rise from the ashes that are never erased. But civilizational forces are also phoenixes that are reborn and renewed, sometimes discreetly, sometimes imposingly full of hope, as evidenced in the work of Paulo Freire and so many Brazilian educators such as Darcy Ribeiro, Anísio Teixeira, Magda Soares, Marilena Chauí, Antônio Cândido and so many others.

It is within a scenario of hope, with eyes open to criticism and attentive to the improvement of the foundations of school education that this article briefly covers the history of educating thinkers. They founded the pedagogical practices to reach the twenty-first century with an optimistic look at the use of ICT in education. But not only to education as an isolated phenomenon, but with a view to society, curricular justice and the ethical value of the sciences. The article brings, as the basis of his field research, experiments that were developed and became public policies in the city of São Paulo.

FOUNDATIONS AND MYTHS OF KNOWLEDGE, LEARNING AND TEACHING

What is knowledge?

Knowledge is the general apparatus of living beings to respond to their needs for escape, food, shelter, the perpetuation of the species, in short, for survival.

As one of the forms of survival of the human being is social aggregation, the knowledge necessary for this purpose also requires learning how (and why) to live in society.

The learning of survival knowledge in human beings has a strong instinctive charge, but requires increasing doses of expansion and improvement that go beyond its survival dimension. Human beings always want to improve their lives. Thus, history shows. Just responding to the demands of external stimuli for survival is not enough for the human. It is also up to him to transmit knowledge from previous generations to future ones, through a utopian and futuristic process. Precisely because he is the most fragile of animals, he had to create a field of knowledge, culture. Memory, language, reflection, writing, science, and the arts make up this list of skills that go beyond instinctive loads.

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Human knowledge is, therefore: the result of the dialogue – sometimes not transparent or very complex – between instincts and culture. Freud (2011), Marcuse (1997) and Fromm (1969) will emblematically place the theme in their studies and essays on the dilemma of civilization versus instincts and desires, fundamental to understanding human procedures.

Knowledge does not have a univocal definition because we are complex in the multiple experiences of its contents, which are segmented into the different areas of care for life and the understanding of the world and its transcendence. Knowledge of language, social knowledge, technical knowledge, artistic knowledge, philosophical knowledge or knowledge of nature, the cosmos and utopias.

The human knowledge, to which we are basically referring here, is of such a wide scope that it goes beyond the competence of any social institution to account for all of them or even to bring them together under a single definition. The family, the artistic institutions, the political, the sports, the health, the physical or military defense, the religion, the academies cannot alone achieve the purposes of education with their contents and purposes. Hence Plato argued that the family could not fully educate a child. They should be educated by professionals. Which is a corollary of the African proverb that says "it takes the whole village to educate a child". The different ways of learning will be divided into parts to make them better understood.

LEARNING AND TEACHING ARE ARTICULATED, BUT THEY ARE NOT EQUAL

You can't say: "I taught the students a lot, but they didn't learn". If they didn't learn, there was no teaching. There may have been words, images, sounds transmitted to the students, but if learning did not take place, there was no teaching.

Just as I cannot say that I learned by studying alone: I learned, but no one taught me. Paulo Freire (1969, p. 131) breaks the logic of these statements when he states: "No one educates anyone, but neither does he educate himself. Men educate each other, mediated by the world."

Such self-learning is a metaphor that, when repeated a lot, resembles the truth. If it is well analyzed, the statement does not hold up. Someone can be very disciplined, have a very well planned and motivated learning project, but they will need books, documents, trips, notebooks, observation instruments, equipment, consultations with libraries, museums, dialogue with peers or researched subjects, documents with photos or

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recordings. You need to submit your data for comparison with other data produced by someone, tested, disclosed, etc.

In this context, thousands of people and institutions built for the so-called "young scholar" the necessary conditions for his studies: they wrote books, published research, deposited data on platforms, presented papers at congresses, maintained equipment, created an App, etc. Imagining to end the rope to the side of this argument, one can conclude by saying that the so-called autodidact of the twenty-first century only exists because Galileo, Gutenberg, the Arab civilization, the Greek civilization and Pasteur happened before him and intentionally left an organization of accessible knowledge.

We could say, in the fashion of the African proverb, that it took the work of the entire culture of humanity for this scholar to fulfill his purposes of "studying alone". He didn't learn on his own. The assimilative effort and the intention to learn is individual, but the general and broad process by which the individual studies is a legacy of all the villages of the world and of all previous times. The path of the legacies left to us in Western civilization by the Greeks, the Romans, the Arabs and the indigenous or autochthonous peoples are the mediators of our efforts and needs to learn (and teach). In this sense, maker learning takes up the long histories of mathematics, the sociology of the arts, the evolutions of technological devices, Artificial Intelligence and makes them available so that learners can have a rich experience free of many arbitrary impositions, built from their problematizations of reality and their interests. Learning is built in solidarity, although without individual, assimilative and motivated work, learning does not take place. The maker methodology seeks the articulation between these two dimensions. And what are the mediations through which these methodologies operate?

In the case of maker learning, "[...] it is an application, based on a technological instrument of the Piagetian proposal, of the formation of systems of assimilation, cooperation, coordination, balance, reversibility, decentralization, among others" (Almeida; Mendonça, 1986, p. 147). This composition of concepts by Piaget (2010), together with the elaboration of the learning processes constructed by Papert (1980, 1985) is called Constructionism. The developments of the concepts, discussed so far, will be broken down later in this article.

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METHODOLOGY

With a qualitative approach, it presents a critical essay and case study through the analysis of the project "The City We Want". This combination of critical essay and case study allows for an in-depth analysis of both the theoretical foundations and practical applications of maker education, providing a comprehensive overview of its impact and challenges.

The article uses a critical essay to theoretically explore the evolution of the maker movement and its philosophical, educational, and historical roots. This part of the study seeks to interconnect the conceptual bases of maker education with contemporary practices. Works by classic and contemporary authors, such as Paulo Freire, John Dewey, Jean Piaget, and Seymour Papert, are used to support critical analysis. It also explores how the different principles of the authors are applied in contemporary maker education

The article presents a case study based on the analysis of the project "The City We Want", implemented in São Paulo with the collaboration of MIT/Media Lab. This project is used as a practical example of the application of the principles of maker education.

CASE STUDY: BRAZIL IN 2001 AND 2017

The city we live in can be the city we want. But this requires analysis, clear conceptual proposals, intelligence and work. It is within this concept that it was created by MIT/Media Lab/Future of Learning[4], for the Municipal Secretariat of the city of São Paulo – Brazil, a project that articulates computational thinking, social actions, the improvement of learning processes, learning through practice-reflected, in short, proposes curricular reformulations and the concept of teaching[5].

The history of the development of maker thinking goes through many mediations elaborated by different actors, in a complex process of evolution. The maker concept applied to education (perhaps differently from other maker spaces) carries within itself the ability to articulate teams. Multidisciplinary teams that, in turn, carry the ideology of commitment to dimensions of cognitive and social impacts of their work.

[4] Information about the project is available at https://www.media.mit.edu/groups/future-of-learning/overview/. Accessed on: 22 jan. 2021.
[5] It can be said, without a doubt, that the set of ideas brought by the MIT/Media Lab in 2001 already contained, in embryo and in practice, the ideas now recognized as maker education.

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This was the case of an episode at the beginning of the twenty-first century, in the city of São Paulo, when a team from the MIT[6], met with the directors of Municipal Public Education[7], including the secretary, to present them with a proposal entitled "The city we want". The vision of the project was based on an ambitious goal presented at the beginning of the document, which emphasized that at the time there was "a moment of rare synergy between the political will of the government, the willingness of civil society, the availability and cost of technologies and the existence of academic training to create, plan and implement this vision [....]" (Soster, 2018, p. 156).

The presentation document of the Proposal "The city we want" brought two reasons that came together to give consistency to the proposals. On the one hand, the structure of the ways of learning at the beginning of the century required transformations in the nature of school activities. On the other hand, the large masses of the population that accessed education in the city of São Paulo demanded significant learning, for all and of quality. This principle was part of the city's public education policy that defended the enormous number of students, teachers and communities involved – they were not against quality education, but rather demanded quality as a public good and not a privilege of some pilot programs. The technology of wide dissemination and of many communicating with many and working for the common good of the city would only bring benefits and innovations to schools and student learning.

Another golden principle of the project was that the city, the communities, the urban districts, the schools and the individuals constituted the most favorable environment for changing daily life through the interference of the significant knowledge of the school and its practices.

In the public school network there was a healthy restlessness in the sense of asking for changes.

Sciences and their languages, technologies, literature, arts, communication, history, geography and their interfaces can be the most effective way to bring new meaning to the school curriculum: the mediation of information and communication technologies became a

[6] The MIT (Media Lab Future of Learning) team that met at the São Paulo Municipal Department of Education in September 2001 was the result of an inter-institutional arrangement also involving the University of São Paulo LSI (Laboratory of Integrated Systems of Physics – represented by Roseli de Deus). It was initially composed of Alice Cavallo, Anindita Basu, Arnan Sipitakiat, David Cavallo, Edith Ackermann, Federico Casalegno, Georgina Echaniz, Jacqueline Karaaslanian and Paulo Blikstein.
[7] At that time (2001), the Secretariat had around 900 schools under its responsibility, involving a network of 1,000,000 students, spread over a city of 10,000,000 inhabitants. At the time, the municipality's Public School Network had 60,000 educators.

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differential in this proposal. The ideas of Papert's Constructionism, of learning-by doing and thinking socially were the foundations that gave security to the project. In this sense, Papert (1985), Paulo Freire (1976, 1996) and Dewey (1979b) were the first theoretical and practical inspirers, closer to this new vision of teaching and learning.

The foundation of everything was in the principle of bringing a project to all schools (which freely adhered to the project) to recognize, analyze and make proposals for the solution of their problems. To think and make the city more humane through technologies. The territory of the megalopolis would be the maker laboratory par excellence. This pedagogical-cognitive process was defended in the document: "[...] one of the pillars of the proposal is the existence of concrete projects, which allow its development to be permeated by an inseparable process of action, reflection and discussion, thus progressing to new actions" (Soster, 2018, p. 157).[8]

Within this vision of knowledge construction, for all, in the direction of social commitment and with the mediation of technologies as an instrument-to-think-with, numerous and emblematic public schools in the city joined the project.

It was launched in 2002, by the mayor of the city, and operated throughout her administration, until 2004, with continuity in the following administrations, although the analysis of its results is not the object of this research[9].

The project was presented to be carried out in four phases.

The first phase was marked by the actions of "Human development (workshops with teachers), identification of partners and location (schools, community centers), fieldwork, choice of the first projects" (Soster, 208, p. 157).

The second phase was very much inspired by an educational and political principle of Paulo Freire that runs through all his work, that utopian thinking is not thinking about the unrealizable, but the one that denounces injustices and is capable of announcing a new, more humane world.

This phase, says the MIT/Media Lab/Future of Learning document "The city we want":

[8] Such a vision of education, born of practice-reflected, was directly in line with the thinking of Paulo Freire, who had been Secretary of Education of the city whose management and program lasted four years (1989-1992).

[9] The Municipal Public School of Heliópolis, Presidente Campos Salles, directed at the time by Professor Brás Rodrigues Nogueira, was the first to join the program, having carried out numerous training courses with the teams of MIT and the LSI/USP Laboratory. The school is still nationally recognized as an example of the integration of school learning with the issues of society and the neighborhood.

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> It begins with the investigation by the students of the network, about the situation of the city through research, conversations with family members, members of the community [...] and from this survey they would create models, videos or art objects materializing their suggestions for the solution of the problems found (Soster, 208, p. 156).

This phase also culminates with an exhibition of the projects and models, to be spread to all the schools in the city involved in the program.

The third phase is called "The city we want and are going to make now". The pedagogical strength of this phase is to take advantage of all the work of modeling and proposing projects made by the students, throughout phase two, to actually implement them in the city, using different technologies. Such activities would go hand in hand with the reflection on the meaning of changes in the curriculum and in the school due to their approximation with the community and with the use of technologies.

RESULTS

The results of the trial and the case study are presented below:

KNOWLEDGE AND PRACTICE: THEIR ARTICULATIONS

Is knowledge a production of the body or the soul? Is it an assignment of the hand or the mind? Which one knows what? Is there specific knowledge of the mind and others of the hand?

Is it the soul or the body that knows? Does knowledge come from some part external to the subject or is it born spontaneously from his innate capacities?

Two markers need to be set to equate answers to such questions.

On the one hand, it can be said that doing precedes thinking. We think about why we do it. But just doing it doesn't justify thinking. Animals all do and have no characteristics of human thought.

Historically, our doing (situations required for the survival of eating, living and living together) has been constructed along with thinking. The more we thought and did, the more we learned to think and do better. The anteriority of doing is merely a way of explaining the beginning of everything, but human doing and thinking have mutually constituted each other. I think better, I do better. I do better, I think better.

Where is the separation between thinking and doing? Where do we need to do it to think better? What do we need to think about in order to do better and do good?

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The valorization of thinking about doing began with the establishment of differentiated power among human beings. This was represented by the separation of activities by hierarchies, privileges, meritocracies and differentiated rewards.

In indigenous communities, the social division of labor is very tenuous, from the point of view of social relations, although the division of labor between men and women is obvious and apparently unequal. Societies such as the Egyptian, 5,000 years B.C., revealed themselves as a highly divided structure and with the modes of work fragmented into different functions that brought, precisely for this reason, the devaluation of the production of enormous social groups. Priests, accountants of the royal treasuries, members of the court, farm workers, merchants, craftsmen, legislators, warriors and generals, sacred castes, scribes, royalty and nobility and their servants. In this brief list of Egyptian social organization, it is seen that some of these social actors "made and produced" materially, rice, bricks and carved stones. Others thought, wrote, warred, and governed in defense of the alleged interest of all. Some of these spoke to the gods or were their representatives. The 'pilots' who worked with their hands were either slaves or second-class citizens. When those who act with their hands are devalued and work for those who "think", live in low survival conditions and the others are valued and have social privileges, it is confirmed that "doing is not good". From this brief example, we have the history of the devaluation of work, of doing and manual labor in relation to the prestige of thinking, of praying, of warring, of speaking. The marks of this division of labor and social rewards remain to this day, diversifying and deepening. Maker education resumes the historical function of manual production as something that belongs to the very constitution of the human being. Its entry into the debate takes place through education and learning, factors that make practice and thought inseparable.

Knowledge and democracy feed each other

Let's go to Greece. The original meaning of the word myth is "truth". Myths were the mainstay of truth among the Greeks. Myths sustained their civilization with regard to the meaning of life, the justifications of wars (medical and punic or family wars among the nobility itself), the clues on how to get out of them and their demands. Its architecture, the ceramic or marble arts, the Olympics, democracy, the Platonic academy, temples and amphitheaters, tragedies and comedies, heroic literature and historiography.

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Their civilization evolved in such a way, between 600 and 300 B.C., that their system of beliefs, values, and political organization were shaken and a process of change began. The cities, more than the countryside, became the aggregating links of Hellenic civilization.

The first formal experience of Athenian democracy from a popular revolt dates back to 508 BC. The apogee of Athens is established between 460 and 430 B.C. in politics, arts, wars and economic vigor. At this time, in addition to the activities of philosophers, the Greek theater will give voice to the people and not only to the fights between noble families, after all Medea, Antigone and Oedipus portrayed intrigues and murders between members of the families of rulers. The people were out. The choir, inaugurated and valued in the Greek theater, brings what the people thought about life and about what the meaning of the polis was. The chorus, composed of people of the people – neither nobles nor gods nor heroes – followed the entire plot of intrigues and murders and criticized the nobility, the gods and their madness. The voice of the people has wisdom. At this moment, philosophy and questions of education arise.

In 428 BC, Plato was born, and in 383 BC, Aristotle was born. The two philosophers bring the greatest clash that has occurred between thinkers about knowledge, learning and their purposes. The clash is due to the divergence of conception about the meaning of practice as a founding element of learning, as we will see below. However, they bring something in common that appears clearly: the idea of knowledge linked to democracy as a political regime and as an individual dimension of learning. Democracy is a condition for learning, for the two philosophers. And without knowledge there is no democracy. This principle will also mark the concept of maker learning, in what was inspired by Papert (1980), as we will see in the second part of this article.

But what knowledge, what democracy?

Plato will bring in the Myth of the Cave, the explanation of how human knowledge occurs. According to him, the men and women are tied by chains inside a dark cave, with their backs to their exit, without being able to look back, where the sunlight comes from. This allows them to only look at the bottom of the cave and see the moving shadows of the outside world projected on its bottom. Therefore, for years, they only see the shadows move, to the point of thinking that the leftovers are reality itself. Furthermore, according to the Myth, if they looked at the sun they would be blinded because they were unaccustomed to so much light.

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The meaning of myth for Plato leads us to state the following about his view of knowledge. What we know are shadows of reality. Man cannot contemplate true knowledge because he has a material body that prevents him from seeing reality. The body is the object of our cognitive limitations. If we did not have the body, we could contemplate reality only with the soul, our best guarantee of knowledge, because it can see where the perfect world of forms (or ideas) exists. The body and the matter, which compose it, are in the sensible world, a world of illusion, beliefs and shadows. True human knowledge is found in the intelligible world of ideas, mathematics, and science (episteme). For him, the less the body intervenes in the cognitive process, the more knowledge will be pure and close to the truth. The Platonic view of the body is marked by distrust, since it is material and therefore corruptible, mortal and limited. The "idealist" mark of Plato's thought is recorded here: only "ideas" lead us to perfect knowledge. The true being is in the world of ideas and perfect forms.

Aristotle (383 B.C.), a disciple of Plato, will oppose his master, stating that the contemplation of perfect forms is not what produces knowledge, but everything begins with the observation coming from the senses (touch, smell, sight, taste and hearing). The body is our first access to the world, because man is not a spirit that has a body, but he, the body, is an essential dimension of the human being. I am a body. The spirit abstracts the experiences of the body, it does not dispense with them. Hence, experience is the basis for the constitution of abstract, formal, scientific or philosophical knowledge, elaborated by mental processes.

Aristotle establishes the idea that there is a hierarchy in the various types of knowledge. Sensations are the first access of the human being to information. The accumulation of these sensations in memory creates experience (empiricism). Therefore, animals that have memory can learn. The repetition of sensory experiences generates practical knowledge (tekné or ars), a knowledge that acts to produce results. The architect's technique produces temples or houses. The politician's technique produces social well-being, just as the teacher's technique produces learning, his own and the student's. The demonstration of the validity of the technique lies in the effects it produces and its effectiveness: the medical technique is proven by the results in health. And that's it. Their falsehood will come from their incompetence.

So far we see that the epistemological roots of maker education is validated by its effectiveness in generating products that highlight the effectiveness of the ability of

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teachers, tutors, digital devices, and learners to generate products that allow them to interpret reality and act jointly on it, mediated by technologies.

Aristotle will also bring a fourth dimension of the theoretical sciences that are not conditioned to their practical applications. The human being, according to the philosopher, elaborates scientific knowledge, as he is capable of establishing an articulation between logical principles and the data of sensations. One cannot walk without the other. Our universal notions originate from the observations of the senses by a process of abstraction, and then can be applied to any other analogous realities. "Even the notions of mathematics are based closely or remotely on real quantities" (Morandini, 1963, p. 409).

Learning is done in the polis, and therefore all its qualities are realized in the collective life of the republic and in democracy. In Book VI, Chapter 4 of Aristotle's Politics, it appears very clearly how life in the city, just and free, sees democracy:

> [...] § 2. Under the law governing democracy, equality means that the rich and the poor have no political privileges, that both are not sovereign exclusively, but that they are all sovereign in exactly the same proportion. If it is true, as many imagine, that liberty and equality are essentially democracy, yet they can be found there only in all their purity, so long as the citizens enjoy the same perfect political equality. But since the people always constitute the most numerous part of the state, it is the opinion of the majority that makes the authority, it is natural that this is the essential characteristic of democracy. [...] (Aristotle, n.d., s.p.).

Therefore, as pointed out earlier, politics and ethics (as care for the common and greater good) are an intrinsic part of learning. These principles will be taken up dozens of centuries later with other philosophers, thinkers and politicians such as Bacon, Comenius, Hobbes, Rousseau, Vygotsky, Piaget, Dewey and Paulo Freire. Two of these thinkers, researchers and philosophers, Comenius and Dewey, will be highlighted here, as well as the foundations from which they draw inspiration for the design of the long path of the theoretical bases of active learning, built personally and socially, in special regimes such as those of schools. What will be added to so many centuries of history, in our case of maker education, will be its computational technological mediations – the internet, personal computers, smartphones, social networks, search engines and surveillance mechanisms – synthetically called Information and Communication Technologies (ICT).

Passing through modernity

Do not think that the conceptual matrices of "Learning by doing" or "Maker learning" are recent inventions and elaborated all at once. The fabric of a long history of a few

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thousand years will be evident here. Two more authors will be brought who contributed to the design of the long plots for the understanding of the components of what is knowledge, what is teaching and what is learning.

What is new in the current scenario are ICTs, inserted in the context of formal school education, in the curricula of different levels of education, in teacher training and in school equipment.

After Greece, represented very briefly by Plato and Aristotle in the 4th century B.C., we now bring Amos Comenius (1592-1670), a theologian born in Moravia (now the Czech Republic) who will defend that studies do not need to be dull, meaningless and full of texts to be memorized, he proposes a teaching model that starts from the idea of unity that underlies all human experience, for everyone can learn everything. (Narodowskl, 2004). The ideal teaching methodology should take into account the development of Science, in partnership with the empiricism of Bacon (1561-1626). Since thought and language go together, the words themselves must, according to Comenius, derive from the objects of personal experience. Because of this, knowledge of the world depends on the cultivation of the senses (touch, smell, sight, taste, hearing), seeking to establish articulations between language and experiences. Thus, the stimulus in contemporary teaching processes is anticipated, the mobilization of apprentices for the elaboration of projects that are born from the observation of daily life, social problems, interpersonal relationships and their manifestations. How to represent the complexity of the relationships of the human being with nature, with the future, with other cultures are the challenges of studies carried out in school environments, at the beginning of the twenty-first century, as a challenge to curricular constructions and the search for their effectiveness and pedagogical meaning. Comenius has as the foundation of his methods, presented in the Didactica Magna (1638), that formal education must include in itself, above all, the education of the poor, in a clearly democratizing perspective. For him, every human creature is rational and can learn everything: "To be a rational creature is to be an observer, denominator and classifier of all things; this means knowing and being able to name and understand everything that the whole world contains" (Didática Magna, 1638, p. 9).

From this, in this very brief summary, Comenius' maker vision can be inferred. Not only does the human being observe, measure, compare, weigh, classify, but he gives a nomenclature to what is lived and observed, so that it can be interpreted and understood, in

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the experience of a long process of construction of personal and universal knowledge, for all.

Dewey: democracy and the purposes of learning

John Dewey's (1859-1952) proposals regarding education are profoundly inspiring for the consistency and coherence developed by maker thinking and methodology.

It starts from questions that guide practices and the search for the purpose of education itself. Dewey's vision takes into account contemporaneity and its complex problems that require a synthesis of evolutions, of the sense of knowledge, produced by the multiple philosophical thoughts that preceded us. To make the proposed synthesis, he returns to the basic questions of philosophy.

Educate for what? Learning for what? Dewey does not defend a utilitarian and short-sighted vision for education. Education (formal, public and general) has an end in itself. I learn because learning is good and worthy. The essential return that education gives me is its own enjoyment. The purpose of someone playing a football match is not victory, nor is their purpose for the game to end. If that were the case, the game would only make sense for those who were victorious; or the simple end of the match would be what was intended. This is a non-finalistic thought as a sense of history. However, his perspectives for answers do not stop there. The purposes are multiple, aiming at adapting to the demands of the civilizing epochs lived or to the ultimate purposes of social life: well-being or happiness, which are a posteriori constructions and unite the different ends lived and desired by education. Dewey insists that "the broader and more differentiated the ends, the more they can be trusted, precisely because they are different illuminations of the same reality" (Cirigliano, 1973, p. 126).

The ends of education are more or less broad, depending on the perspective from which we look at them: the ends of an economic epoch, those of a religious pattern, of an individual intention or of a moment of war.... The answer is multipurpose.

Dewey goes on to ask: Could a human being live without knowing why he lives? Or could he live simply? Would you start with action and then discover the purpose through the educational experience itself? The implicit answer is yes.

The mentor of an educational program may have a clear objective, but the learner can create experiences to execute those objectives in an ambiguous and disconnected way in relation to the achievement of the initially proposed ends. There are always great

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purposes of society and its times (economic, religious, individual or cultural...). In addition, the ends of education itself coexist (literacies, sciences, autonomous thoughts, coexistence of learning networks, etc.).

However, among all the complex purposes of education, Dewey will highlight a special and broad one: to create an environment to release flexible, varied and innovative activities that allow the learner to have democratic and diverse experiences as society requires, such as, for example, sharing as much as possible "common interests" and "openness to other groups" (whatever they may be...).

In brief summary, the proposal that most fundamentally marks the motor and finalistic idea of education is democracy, based on the basis on which we live in a society of change and for change. "There is no end to development and change other than themselves, seen as social progress. The educational element that brings within itself a synthesis of the purposes of education is democracy.

Dewey (1979a, p. 93) will peremptorily state, when justifying democracy as a purpose of education, that: "A democracy is more than a form of government: it is primarily, a form of associated life of joint and mutually communicated experience".

In the structural values brought by Seymour Papert in all his vast educational work around the world (Vietnam, Nigeria, France, the outskirts of large North American cities, Brazil...), Dewey's contributions can be seen. His work and influence appear notably in the idea that everyone can learn; that everyone can learn by doing what appears to them as a value and as long as they can understand its purposes. But in addition, maker projects are impregnated with a character of change, creation and acceptance of what is different, a value synthesized in the idea of education for democracy. Aristotle is brought back again, at the end of this brief history of some educators who influence the proposals of maker education, talking about Politics and democracy:

> [...] § 1252a. Since every city is a kind of association, and since every association is formed with a view to some good (for all men always act with a view to something which appears to them to be a good), it is clear that, if all associations aim at a certain good, then that which is the highest of all, and embraces all the others, is precisely that which aims at the highest good of all; it is called a city (polis), or political community (Aristotle, idem, ibidem).

And completing Aristotle, it can be said that Politics and Democracy are also essential components of Education – and that they are contained in maker learning methodologies. Free experimentation, work with projects born from the problems brought by

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students and the vision of the social commitment to education mark the maker learning methods. Such methods, in historical terms, are in the process of being built and perfected. And it is within the perspective that such a method is continuously built that this article presents its contribution of research and reflection.

Democracy, in the broad sense of the term, can be the way of living social practices that point to the political dimension of education, as will be seen below, in the report of the experience "the city that we want", carried out in São Paulo, Brazil, and the experiment-research reported in this article.

Learning by doing in current times

The maker movement, as pointed out, emerged in the United States in the early 2000s, with the work of Neil Gershenfeld (2005) at the Massachusetts Institute of Technology (MIT) as one of its founding milestones. Gershenfeld and his team initiated an innovative project that culminated in the creation of the first Fab Labs (fabrication laboratories), collaborative spaces where anyone could design and manufacture objects using accessible digital fabrication technologies, (Gershenfeld, 2005). These labs were conceived as a means to democratize technology and encourage open innovation, allowing individuals from different backgrounds and levels of expertise to become creators and developers of technological solutions.

Over time, the concept of Fab Labs and the "DIY" philosophy evolved into a collaborative practice, known as "do it with others" (DIWO), highlighting the importance of teamwork and co-creation to solve problems in innovative ways (Troxler, 2014). This evolution has been driven by increasing access to digital manufacturing technologies, which have become cheaper and easier to use, facilitating the diffusion of Fab Labs around the world. The author also highlights the relationship between the maker movement, digital fabrication and changes in production models, pointing to a "third industrial revolution" in which production becomes more decentralized and collaborative. It is noted here the constant tendency to bring the ideals of the factory world (3rd industrial revolution) as a model for the school. This can be considered a deviation from the values outlined by educators who would never defend the standards of the changes of the industrial world to be applied for the purposes of the school.

Technologies central to the maker movement include 3D printers, laser cutters, robotics kits, and other electronic digital fabrication equipment. These tools have become

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increasingly accessible to the general public, allowing people without in-depth technical training to design and manufacture their own products (Gershenfeld, 2012). The use of open source software and hardware has been a crucial aspect, as it facilitates the replication and adaptation of technologies to different contexts and realities (Blikstein, 2013).

In addition to manufacturing technologies, the maker movement is sustained by a learning culture that favors collaborative practice, but within the objectives of education and social commitment. This approach encourages participants to engage in processes of experimentation, prototyping and sharing of ideas, promoting an environment where learning is understood as a continuous and collective process. (Dougherty, 2013).

The maker movement, especially in its integration with contemporary education, is based on educational theories that prioritize active learning and the construction of knowledge, with roots in the works of John Dewey, Jean Piaget, and Seymour Papert. These authors laid the foundations for pedagogical practices that value practical experience, experimentation and creation, central elements for the maker philosophy.

The contributions of John Dewey (1859-1952) are crucial. In his work Experience and Education (1979a), Dewey proposed that learning should be an active and reflective activity, in which students are directly involved in situations that demand the application of theoretical knowledge in practical contexts. He argued that "education is not a preparation for life; it is life itself," highlighting that learning occurs in a more meaningful way when students have the opportunity to explore, experiment and solve real problems (Dewey, idem). This philosophy is directly reflected in the Fab Labs, where participants develop tangible solutions to concrete challenges, transforming abstract ideas into material products through collaborative practices and experimentation. As highlighted by Ribeiro (2015), "Dewey's pedagogy proposes the junction between practical experience and critical reflection, principles that resonate strongly in maker education, by allowing learning to occur through engagement and action" (Ribeiro, 2015, p. 82).

The work of Jean Piaget (1896-1980) contributed significantly to this view by proposing the concept of constructivism. The author argued that knowledge is actively constructed by the individual through continuous interaction with the environment. In Psychology and Pedagogy (2010), he describes cognitive development as a dynamic process of construction, in which students build their own understandings from concrete experiences and successive reorganizations of their understanding. This theory is central to

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maker education, as it encourages experimentation and the construction of knowledge from direct involvement with the physical world. The maker practice, by encouraging students to design and manufacture objects, acts as an "organizer and provocateur" for constructivist learning, providing an environment where the exploration and manipulation of materials are fundamental to learning.

Seymour Papert (1928-2016), a student of Piaget, expanded on this approach by developing the concept of constructionism. The author introduced the idea that learning becomes deeper and more meaningful when students are engaged in the creation of tangible artifacts, such as prototypes, robots, or digital projects. Papert argues that by building something concrete and meaningful, students not only apply the knowledge but also develop a deeper, more personalized understanding. This approach goes beyond constructivism by emphasizing the importance of doing as a learning process, where reflection and action are integrated. Paft's constructionism (1980, 1985) highlights the crucial role of the act of building as a means of learning, transforming the classroom into a space for experimentation and innovation. In the Fab Labs and other maker education spaces, the constructionist philosophy is at the heart of the activities, as it encourages students to explore, test and share their creations, promoting collaborative and active learning. It is worth noting here that the structure of Papert's proposals refers to programming as structuring thought, mediated by the problematization of tasks.

The integration of the maker movement with education was deepened by Paulo Blikstein (2013), who developed the concept of FabLearn. Inspired by the principles of Fab Labs, FabLearn adapts these practices to the school context, promoting the use of a combination of digital, analog and manufacturing tools for the development of practical projects or prototypes by students and teachers. Blikstein (2013) argues that digital fabrication practices have the potential to democratize access to technology and promote a more inclusive and transformative education, enabling students to develop skills such as creativity, critical thinking, and collaboration.

Another essential concept in maker education is interdisciplinarity, as an example, maker education is articulated with the STEAM methodology, an educational approach that integrates five areas of knowledge: Science, Technology, Engineering, Arts, and Mathematics (Yakman, 2018). Judith A. Ramaley (2001), who helped to spread the use of the term and promote initiatives that reinforced the integration of STEM in the school curriculum, points out the need to encourage an educational approach that better reflects

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the real world, where these disciplines are interconnected and essential for innovation and economic development. Currently, the acronym STEM has been added to an a (arts) with the aim of emphasizing that disciplines such as design, music, theater, and visual arts can contribute to the development of important skills, such as creativity, critical thinking, problem-solving, and communication.

Maker education, in this way, is articulated with the STEAM approach by promoting "hands-on" learning, in which students not only learn theoretical concepts, but apply them in the creation of prototypes, experiments, and technological solutions. This practice strengthens interdisciplinarity, allowing students to explore connections between science, technology, and the arts while developing essential skills for the twenty-first century. This approach promotes active and practical learning, where students not only absorb knowledge, but apply it in concrete and meaningful projects (Martínez; Stager, 2013).

Maker education is based on several pedagogical principles, among which the ideas of Paulo Freire stand out. Freire proposed an educational approach that values the active participation of students in the learning process, emphasizing the development of critical awareness and the possibility of social transformation. These elements dialogue directly with the maker philosophy, which is guided by the autonomy of the learner and the practical application of knowledge in concrete and contextualized projects. The life of peasants, slum dwellers and sugarcane cutters in the Brazilian Northeast were the first source of experience of concrete and the context from which one read the world and participate in it.

Freire (1974) argues that education should be a dialogical and emancipatory process, in which students are encouraged to reflect critically on their realities and to develop skills that enable them to intervene in them. This conception is opposed to the abstract model of teaching, in which knowledge is transmitted in a unidirectional and teacher-centered way to the student. In Freire's perspective, learning must occur in a collaborative and participatory way, promoting reflection and action (praxis) as central elements of the educational process.

Blikstein (2018) expanded on these ideas by adapting them to the contemporary context of digital fabrication and project-based learning. He notes that maker education can be an effective tool to promote students' autonomy and protagonism, by providing opportunities for them to develop technical and creative skills by creating solutions to concrete problems in students' communities. In this context, maker education enables

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students to use technology not only as a technical tool, but as a means to exercise their creativity and to address relevant social issues.

In maker spaces, the practice of dialogue is essential for the development of collaborative projects. Students work in groups, discuss ideas, solve problems and, through this exchange, build new knowledge. The maker practice, therefore, promotes a learning environment that values active contribution and critical engagement, central concepts in Freire's theory of education.

Freire argues that education should promote the autonomy of students, enabling them to be protagonists of their learning process. This autonomy is encouraged in maker education, which is structured around the relative autonomy of students to explore, experiment, and learn through hands-on activities. In addition, it offers a space where error, uncertainty, and doubt are seen as part of the learning process, allowing students to develop the capacity for dialogue, resilience and problem-solving skills when creating prototypes and testing their ideas.

Another relevant aspect of Freire's contributions is the defense of an education that promotes social inclusion and justice. For Freire, education should be a means of reducing inequalities, allowing all individuals to have access to knowledge and development opportunities. Similarly, maker education contributes to social inclusion by democratizing access to digital fabrication technologies.

Blikstein (2018) suggests that, for maker education to reach its full transformative potential, it is essential that it be accessible and inclusive, promoting initiatives that expand access to tools and resources, especially for populations that historically have fewer opportunities to access technologies and other societal gains. Maker spaces can function as hubs of innovation and inclusion, where students from diverse backgrounds have the opportunity to develop their skills and apply their knowledge to create solutions that benefit their communities.

Project-based learning (PBL) is a methodology that stands out in the context of maker education. Instead of learning concepts in isolation, students are encouraged to apply theoretical knowledge in the creation of practical and collaborative projects. According to Blikstein (2018), PBL allows students to test, fail, and adjust their creations in an iterative learning cycle, which is a fundamental skill in the contemporary world.

Maker education proposes a curriculum that puts students' interest and curiosity at the center of the learning process. This approach is grounded in the idea that learning

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becomes more meaningful when students can explore topics that pique their natural curiosity and personal relevance. A maker curriculum, therefore, enables more personalized learning, where students are encouraged to follow their collectively debated and presented interests and thus develop a sense of ownership over their learning. The concept of Interest-Driven Curriculum, although not attributed to a single theorist, emerges from a pedagogical tradition that values student-centered learning, a concept built over decades, influenced by thinkers who believed in the importance of autonomy, experience, and social interaction in the educational process.

Valente, Bliksteirn and Meireles (2020) highlight that maker education needs to be seen as a practice that can be integrated into the curriculum. They suggest that the maker movement provides a rich environment to develop interdisciplinary skills, such as creativity, critical thinking, and problem-solving, which are essential for the education of students in the twenty-first century.

CASE STUDY: BRAZIL IN 2001 AND 2017

The city we live in can be the city we want. But this requires analysis, clear conceptual proposals, intelligence and work.

It is within this concept that it was created by MIT/Media Lab/Future of Learning[10], for the Municipal Secretariat of the city of São Paulo – Brazil, a project that articulates computational thinking, social actions, the improvement of learning processes, learning through practice-reflected, in short, proposes curricular reformulations and the concept of teaching[11].

The history of the development of maker thinking goes through many mediations elaborated by different actors, in a complex process of evolution. The maker concept applied to education (perhaps differently from other maker spaces) carries within itself the ability to articulate teams. Multidisciplinary teams that, in turn, carry the ideology of commitment to dimensions of cognitive and social impacts of their work.

This was the case of an episode at the beginning of the twenty-first century, in the city of São Paulo, when a team from the MIT[12], met with the directors of Municipal Public

[10] Information about the project is available at https://www.media.mit.edu/groups/future-of-learning/overview/. Accessed on: 22 jan. 2021.
11 It can be said, without a doubt, that the set of ideas brought by the MIT/Media Lab in 2001 already contained, in embryo and in practice, the ideas now recognized as maker education.
12 The MIT (Media Lab Future of Learning) team that met at the São Paulo Municipal Department of Education in September 2001 was the result of an inter-institutional arrangement also involving the University

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Education[13], including the secretary, to present them with a proposal entitled "The city we want".

The vision of the project was based on an ambitious goal presented at the beginning of the document, which emphasized that at the time there was "a moment of rare synergy between the political will of the government, the willingness of civil society, the availability and cost of technologies and the existence of academic training to create, plan and implement this vision [....]" (Soster, 2018, p. 156).

The presentation document of the Proposal "The city we want" brought two reasons that came together to give consistency to the proposals. On the one hand, the structure of the ways of learning at the beginning of the century required transformations in the nature of school activities. On the other hand, the large masses of the population that accessed education in the city of São Paulo demanded significant learning, for all and of quality. This principle was part of the city's public education policy that defended the enormous number of students, teachers and communities involved – they were not against quality education, but rather demanded quality as a public good and not a privilege of some pilot programs. The technology of wide dissemination and of many communicating with many and working for the common good of the city would only bring benefits and innovations to schools and student learning.

Another golden principle of the project was that the city, the communities, the urban districts, the schools and the individuals constituted the most favorable environment for changing daily life through the interference of the significant knowledge of the school and its practices.

In the public school network there was a healthy restlessness in the sense of asking for changes.

Sciences and their languages, technologies, literature, arts, communication, history, geography and their interfaces can be the most effective way to bring new meaning to the school curriculum: the mediation of information and communication technologies became a differential in this proposal. The ideas of Papert's Constructionism, of learning-by doing and thinking socially were the foundations that gave security to the project. In this sense, Papert

of São Paulo LSI (Laboratory of Integrated Systems of Physics – represented by Roseli de Deus). It was initially composed of Alice Cavallo, Anindita Basu, Arnan Sipitakiat, David Cavallo, Edith Ackermann, Federico Casalegno, Georgina Echaniz, Jacqueline Karaaslanian and Paulo Blikstein.

13 At that time (2001), the Secretariat had around 900 schools under its responsibility, involving a network of 1,000,000 students, spread over a city of 10,000,000 inhabitants. At the time, the municipality's Public School Network had 60,000 educators.

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(1985), Paulo Freire (1976, 1996) and Dewey (1979b) were the first theoretical and practical inspirers, closer to this new vision of teaching and learning.

The foundation of everything was in the principle of bringing a project to all schools (which freely adhered to the project) to recognize, analyze and make proposals for the solution of their problems. To think and make the city more humane through technologies. The territory of the megalopolis would be the maker laboratory par excellence. This pedagogical-cognitive process was defended in the document: "[...] one of the pillars of the proposal is the existence of concrete projects, which allow its development to be permeated by an inseparable process of action, reflection and discussion, thus progressing to new actions" (SOSTER, 2018, p. 157)[14]

Within this vision of knowledge construction, for all, in the direction of social commitment and with the mediation of technologies as an *instrument-to-think-with*, numerous and emblematic public schools in the city joined the project.

It was launched in 2002, by the mayor of the city, and operated throughout her administration, until 2004, with continuity in the following administrations, although the analysis of its results is not the object of this research[15].

The project was presented to be carried out in four phases.

The first phase was marked by the actions of "Human development (workshops with teachers), identification of partners and location (schools, community centers), fieldwork, choice of the first projects" (Soster, 208, p. 157).

The second phase was very much inspired by an educational and political principle of Paulo Freire that runs through all his work, that utopian thinking is not thinking about the unrealizable, but the one that denounces injustices and is capable of announcing a new, more humane world.

This phase, says the *MIT/Media Lab/Future of Learning* document "The city we want":

It begins with the investigation by the students of the network, about the situation of the city through research, conversations with family members, members of the community

14 Such a vision of education, born of practice-reflected, was directly in line with the thinking of Paulo Freire, who had been Secretary of Education of the city whose management and program lasted four years (1989-1992).

15 The Municipal Public School of Heliópolis, Presidente Campos Salles, directed at the time by Professor Brás Rodrigues Nogueira, was the first to join the program, having carried out numerous training courses with the teams of MIT and the LSI/USP Laboratory. The school is still nationally recognized as an example of the integration of school learning with the issues of society and the neighborhood.

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[...] and from this survey they would create models, videos or art objects materializing their suggestions for the solution of the problems found (Soster, 208, p. 156).

This phase also culminates with an exhibition of the projects and models, to be spread to all the schools in the city involved in the program.

The third phase is called "The city we want and are going to make now". The pedagogical strength of this phase is to take advantage of all the work of modeling and proposing projects made by the students, throughout phase two, to actually implement them in the city, using different technologies. Such activities would go hand in hand with the reflection on the meaning of changes in the curriculum and in the school due to their approximation with the community and with the use of technologies.

DISCUSSION

It is evident that a set of concepts (and practices) are involved in maker education, which, when implemented in different learning contexts, the different actors recontextualize their theoretical bases by incorporating new looks and new concepts, in a movement of innovation and constant evolution, vectored by social issues.

This article does not include an analysis of the results of the project based on the dozens of schools in which it was worked, but it is worth noting that after almost 20 years, the marks of quality of the work, of the formation of experiments in inter-institutional articulations, are still and increasingly present in the Municipal Public Network of São Paulo, through the curricular reforms that took place between 2001 and 2017.

In the 2016 curricular reform, the material produced in the text on Informatics for Learning that guides the almost 1,000 teachers - Educational Informatics Advisors (POIE) - existing in the Network and who teach how to integrate the curricular space with the use of Technologies in all nine years of Elementary School and even in Early Childhood Education[16].

In the book "Didactic Guidelines of the City Curriculum: Technologies for Learning", the training manual and work guide for teachers contains:

> The first movements involving robotics in the Municipal Department of Education took place between 2001 and 2014, with the project "The city we want". The objective of the project was to observe the city of São Paulo, seeking solutions to

[16] The book is a work and planning guide for the Network's Educational Informatics Advisor teachers, it was written by a large team of SME specialist teachers. University professors and researchers have already dedicated themselves to the theme, advising the Secretariat itself since the beginning of the project (2001), such as prof. José Armando Valente.

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> the problems of the metropolis. Through the LOGO language and from the premises of constructionism, the students sought solutions and created different prototypes with different materials. In 2014, there was a rescue of the Project "The city we want" involving specific training in Scratch programming, developed by MIT, which at the time was gaining an international dimension (São Paulo, 2018, p. 16).

In the same book, important chapters that refer to project-based learning gain space, as well as: chapters referring to robotics, gamification and a special entitled "Maker Culture: educational possibilities".

The guiding text of the Municipal Department of Education states, eighteen years after the initial proposal of the MIT/Media Lab/Future of Learning:

> Maker Culture is about doing, thinking of solutions, creating, collaborating, sharing, interacting with the world. At school, the perspective of this culture is in the possibility for students to experience cycles of projects, with learning, happening in groups according to the interests or problems of everyday life. Collaborative learning enables interaction and empathy (São Paulo, 2018, p. 21).

In 2017, SME transformed three computer labs into maker spaces based on the Digital Education Laboratory (LED) Project. According to the Lemann Foundation (2020, p. 6), an LED can be defined as:

> A classroom designed to stimulate interaction between students and make them protagonists of the teaching-learning process. It has tools such as laptops, a 3D printer, a laser cutter, a drill, and robotics kits. There, with the guidance of the teachers, students are encouraged to test hypotheses for the questions presented in class and to develop projects in order to prove them - whether to understand the process of an electric current, or to create a robot, from paper to prototypes, for example.

Old computer rooms were transformed into maker spaces with the aim of using technology as a teaching enhancer to stimulate interaction between students and make them protagonists of the teaching-learning process.

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Figure 1 - Digital Education Laboratory

Source: LED Guide of the Lemann Foundation (2020, p. 6).

Chart 1 shows the comparison between the two projects:

Chart 1 - Comparison between the Project The city we want and the Project "Digital Education Laboratory"

	Project The city we want[17]	Digital Education Laboratory Project
Year	2001	2017
Local	Public schools in the municipal network of São Paulo and schools managed by the Bradesco Foundation	Unified Educational Centers (CEU) Pera Marmelo, Feitiço da Vila and Capão Redondo
Adhesion	Voluntary	Compulsory
Public	Schools and teachers interested in the project. Fifty schools plus forty of the Bradesco Foundation	Educators from the three laboratories of the schools of São Paulo and trainers from the Municipal Department of Education
Impacted students	1 million students	Awaiting SME report – contact Regina on 01/22/21 or we consult or ...???
Objective(s)	Create a learning environment based on the interests of the participants in which they could build computer models to express their ideas. Reconnect schools to communities through projects. Develop in students the belief that they can positively impact the environment	Use technology as a teaching enhancer to stimulate interaction among students and make them protagonists of the teaching-learning process

[17] Information from Cavallo (2004).

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Theoretical Basis	Constructivism (Piaget, [7]), critical consciousness through involvement with the environment by Freire (1972), constructionism by Papert (1991)	Learning based on the constructionist theory of Seymour Papert from the MIT Media Lab (USA), FabLearn digital fabrication educational program, created by Professor Paulo Blikstein, from Stanford University (USA) that is also based on the constructionist theory
Curriculum	No direct integration. The school was free to decide whether the project could be integrated with areas of knowledge from the regular class schedule or extracurricular	Proposal aligned with the new curriculum of the municipal network, built from the guidelines established in the National Common Curriculum Base (BNCC)
Learning methodology	Approach based on real-world problems as objects of study (Rhem, 1988), contextualizing the problems within projects	Creative learning is a teaching methodology based on the so-called 4Ps: Playful Thinking, Passion, Peer Learning, Project-Based Learning
Materials	*Gogo board*, *low tech*, scrap, disassembled equipment and electronic parts, mechanical devices	Laptops, 3D printer, laser cutter, drill and robotics kits. Space characteristics: tables and stools, work materials, computers, internet, acoustics, temperature
Training	Seminar to present and discuss concepts and demonstrate possible technologies and projects. Workhops in the laboratory of Poli-USP together with first-year engineering students. Acquisition of materials together with teachers and students. Documentation of the process, ideas and tools for the next class, carried out by the teachers.	Module 0: Guidelines and constructions on safety protocols. Orientation and experimentation of tools and machines in the rooms. Survey of demands and expectations regarding the use of space as a whole. Module 1: Reverse engineering activity, with dismantling of electronic scrap and analysis of its parts, purposes and complexities (i.e., taking a closer look, exploring complexities and finding opportunities). Following the Agency by Design approach, educators recorded what was learned and shared the associated knowledge, focusing on the importance of recording. Module 2: Construction of the automated hand with Arduino, protoboard board, servo motors and laser cutter, based on a sensory experiment. Module 3: Experimentation with light-emitting diode (LED), paper circuits and *Makey-Makey programming and physical computing kit*. Module 4: Construction of the wooden bench and cell phone holder, passing on the safety protocols. Module 5: Dive into the processes and critical use of 3D printing, modeling challenges, as well as design examples and problem solving.

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Lessons learned	The students, by disassembling equipment, learned how they work and were empowered to incorporate them into their projects	Integration of the curriculum, training and engagement of educators, extra support inside and outside the LED, participation of IT, appreciation of autonomy. Gains perceived by teachers: class integration, autonomy, student interest.

Source: Prepared by the authors.

This is the greatest and most present testimony of the possibility of building, from the school and its curriculum, "a city that one wants from the city in which one lives", through knowledge and mediated by Technologies.

LIMITATIONS AND BARRIERS TO THE IMPLEMENTATION OF LARGE-SCALE MAKER PROJECTS IN BRAZIL

The difficulties of applying new theories that suppose large investments in material resources and salaries cannot fall on their students, their families, or teachers and the school. The difficulties listed are due to the social organization and economic distribution itself and to the disputes resulting from urban expropriation that prevent or structurally limit access to digital networks, overload the working hours of low-income families and the low salaries of educators. They cannot be attributed to the school and its curriculum, but to the unfair structure of sharing the goods produced in the 9th economy in the world.

Although the maker movement has consolidated itself as an educational approach considered innovative, with adoption in several public and private schools and in non-formal education spaces, its implementation faces complex challenges that require critical analysis.

The implementation of large-scale maker projects in Brazil faces several barriers, especially in low-income contexts, not only the use of appropriate methodologies, but the organization of school knowledge itself.

Although the maker movement is celebrated for its inclusive and democratizing approach, some factors limit its expansion in an equitable way across the country. An analysis of the main barriers points to issues related to infrastructure, educator training, financial sustainability, inequality in access to technology, and institutional support.

A persistent challenge for the implementation of maker education is the financial maintenance and technological infrastructure. Establishing and maintaining a maker space requires ongoing investments in equipment and materials. In addition, constant

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technological updating is necessary to ensure that the tools are efficient and safe for users. However, many schools, particularly in regions with lower purchasing power, lack the financial resources to acquire and maintain this infrastructure. Logistical issues such as the lack of high-speed internet connectivity make it unfeasible to use many digital tools necessary for maker projects. The disparity in the distribution of technological resources between urban and rural schools or in low-income communities represents a significant challenge to the expansion of maker education in a fair and equitable manner.

Teacher training continues to be one of the most critical points for the implementation and sustainability of maker education. Educators need training to integrate maker methodologies into their pedagogical practices, especially digital fabrication. Without continuous training, maker education risks being limited to punctual and superficial activities, without meaningful integration into the curriculum.

Socioeconomic inequality is one of the factors that most limit the expansion of maker projects in low-income contexts. Although the maker philosophy promotes the idea that everyone can learn and create, the reality in Brazil is that access to digital technologies is still a privilege of the few. The high cost of equipment and the lack of basic infrastructure mean that many schools are excluded from maker initiatives.

Based on a deeper analysis of the structural and pedagogical limitations involved, Blikstein and Valente (2020) argue that the integration of maker education into the curriculum requires not only resources. They suggest that maker education can be a way to rethink the curriculum, incorporating interdisciplinary practices that encourage innovation, creativity, and problem-solving.

CONCLUSION

This article explored the evolution of the maker movement, especially in two experiences in Brazil, connecting its philosophical origins to contemporary educational practices and demonstrating how historical principles of "learning by doing" remain relevant in the implementation of current educational projects. Starting from an analysis that integrated philosophical traditions of classical and contemporary authors, the article sought to present a comprehensive view of the theoretical bases that support maker education, as well as its practical applications, especially in the Brazilian context. He thus showed that the foundations of critical and creative education are always built from doing and reflecting on doing.

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The novelty in the maker model is that ICT presents itself as special mediators in this process. Programming, images, speed of calculations, playfulness, collaboration, freedom of choice, everything creates the possibility of truly meaningful learning.

These objectives were fulfilled throughout the text, initially through a detailed review of the history of the concept of "active learning", from Greek philosophy to contemporary thinkers such as Dewey, Piaget, Papert and Freire. This theoretical basis allowed us to establish an evolutionary line of the maker movement and to show how the educational philosophy of different historical periods influenced the development of practices that value autonomy, freedom, concern with local problems, experimentation and creativity. By addressing the articulation between these concepts and the concrete projects analyzed, the article also sought to demonstrate how maker education promotes contextualized and critical learning, due to its possible engagement with society.

One of the central points, the analysis of the project "The City We Want", brings an example of how the principles of maker education were already practiced in educational spaces in Brazil, even before their formal conceptualization. The case study illustrates the practical example of the theoretical principles discussed earlier, showing how the maker approach can be used to develop collaborative projects that involve not only the acquisition of technical skills, but also critical reflection on the environment and society. The interdisciplinary and collaborative approach of the project reflects the essence of the maker movement, which values co-creation and experimentation as central elements of the learning process.

However, barriers and limitations to a massive adoption of maker education in Brazil stand out, it faces substantial challenges that need to be addressed with coordinated and sustainable strategies. Such structural obstacles are organized and have been perpetuated outside the school. And it cannot be responsible for the non-growth of its creative or libertarian methodologies. To overcome these barriers, it is essential that inclusive public policies are developed that encourage continued funding, teacher training, and the creation of infrastructure that allows equitable access to technologies. In addition, it is essential that maker projects are adapted to local realities, considering the economic and social limitations of the communities in which they are inserted. Collaboration between schools, universities, businesses, and governments can contribute to overcoming these inequalities and ensure that schools and maker education mediations fully realize their transformative potential, especially in low-income contexts.

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REFERENCES

1. Almeida, F. J. de, & Mendonça, M. do C. (1986). Logo: Teoria e prática - Coleção o Computador na Escola. São Paulo: Scipione.

2. Aristóteles. (n.d.). A política. Rio de Janeiro: Ediouro.

3. Aristóteles. (1998). Política (A. C. Amaral & C. C. Gomes, Trans.). Lisboa: Ed. Vega.

4. Blikstein, P. (2013). Digital fabrication and 'making' in education: The democratization of invention. In J. Walter-Herrmann & C. Büching (Eds.), FabLab: Of machines, makers and inventors (pp. XX–XX). Bielefeld: Transcript Publishers.

5. Blikstein, P. (2014). Viagens em Troia com Freire: A tecnologia como um agente de emancipação. Educação e Pesquisa, 42(3), 837–856.

6. Blikstein, P. (2018). Maker movement in education: History and prospects. In M. J. de Vries (Ed.), Handbook of technology education (pp. 419–437). Cham: Springer.

7. Cavallo, D., & et al. (2004). The city that we want: Generative themes, constructionist technologies and school/social change. In IEEE International Conference on Advanced Learning Technologies, 2004 Proceedings (pp. 1034–1038). Joensuu. Available at: https://www.researchgate.net/publication/221424184 Retrieved on November 25, 2020.

8. Comenius, J. A. (1997). Didáctica magna. México: Porrúa.

9. Cirigliano, G. (1973). Filosofia de la educación. Buenos Aires: Editorial Humanitas.

10. Dewey, J. (1976). Vida e educação (A. Teixeira, Trans.). São Paulo: Editora Nacional.

11. Dewey, J. (1979a). Democracia e educação (A. Teixeira & G. Rangel, Trans., 4th ed.). São Paulo: Editora Nacional.

12. Dewey, J. (1979b). Experiência e educação (3rd ed.). São Paulo: Cia. Editora Nacional.

13. Dougherty, D. (2013). The maker mindset. In M. Honey & D. E. Kanter (Eds.), Design, make, play: Growing the next generation of STEM innovators (pp. 47–XX). New York: Routledge.

14. Freire, P. (1969). Papel da educação na humanização. Revista Paz e Terra, (9), 123–132.

15. Freire, P. (1974). Pedagogia do oprimido. Rio de Janeiro: Paz e Terra.

16. Freire, P. (1976). Educação como prática da liberdade (6th ed.). São Paulo: Paz e Terra.

17. Freire, P. (1996). Pedagogia da autonomia: Saberes necessários à prática educativa. São Paulo: Paz e Terra.

18. Freud, S. (2011). O mal-estar na civilização. São Paulo: Penguin-Companhia.

19. Fromm, E. (1969). A revolução da esperança: Por uma tecnologia humanizada. Rio de Janeiro: Zahar.

20. Fundação Lemann. (2020). Laboratório de educação digital – Guia completo. Available at: https://fundacaolemann.org.br/materiais/laboratorio-de-educacao-digital-guia-completo Retrieved on January 21, 2021.

Revista ARACÊ
ISSN: 2358-2472

21. Gershenfeld, N. (2005). Fab: The coming revolution on your desktop—From personal computers to personal fabrication. New York: Basic Books.

22. Marcuse, H. (1997). Cultura e psicanálise (3rd ed.). Rio de Janeiro: Paz e Terra.

23. Martínez, S. L., & Stager, G. (2013). Invent to learn: Making, tinkering, and engineering in the classroom. Torrance: Constructing Modern Knowledge Press.

24. Morandini, F. (1963). Crítica. Romae: Aedes Universitatis Gregorianae.

25. Narodowski, M. (2004). Comenius & a educação. Belo Horizonte: Autêntica.

26. Papert, S. (1980). Mindstorms: Children, computers and powerful ideas. [S.l.]: Basic Books.

27. Papert, S. (1985). Logo: Computadores e educação. São Paulo: Brasiliense.

28. Papert, S. (1991). Introduction. In I. Harel & S. Papert (Eds.), Constructionism: Research reports and essays, 1985-1990 (pp. 1–XX). New Jersey: Ablex Pub. Corp.

29. Piaget, J. (2010). Psicologia e pedagogia (10th ed.). São Paulo: Forense Universitária.

30. Rhem, J. (1988). Problem-based learning: An introduction. National Teaching and Learning Forum, 8(1).

31. São Paulo. Secretaria Municipal de Educação. (2018). Orientações didáticas do currículo da cidade: Tecnologias para a aprendizagem. São Paulo: SME/COPED. Available at: http://portal.sme.prefeitura.sp.gov.br/Portals/1/Files/50727.pdf Retrieved on February 2, 2018.

32. Ramaley, J. A. (2001). Why STEM matters. U.S. National Science Foundation (NSF). Available at: https://www.nsf.gov Retrieved on October 19, 2024.

33. Ribeiro, M. (2015). Pedagogia de projetos e a educação maker: Interfaces e inovações. Curitiba: Appris.

34. Soster, T. (2018). Revelando as essências da educação maker: Percepções das teorias e das práticas [Doctoral dissertation, Programa de Estudos Pós-Graduados em Educação: Currículo, Pontifícia Universidade Católica de São Paulo]. São Paulo.

35. Troxler, P. (2014). Making the third industrial revolution: The struggle for polycentric structures and a new peer production common in digital manufacturing. Journal of Peer Production, (5). Available at: http://peerproduction.net/issues/issue-5-shared-machine-shops/ Retrieved on October 19, 2024.

36. Valente, J. A., Blikstein, P., & Moura, É. M. de. (2020). Educação maker: Onde está o currículo? e-Curriculum, 18(2), 523–544. https://doi.org/10.23925/1809-3876.2020v18i2p523-544 Retrieved on October 19, 2024.

37. Von Hippel, E. (2005). Democratizing innovation. Cambridge, MA: MIT Press.

38. Yakman, G. (2008). STEAM education: An overview of creating a model of integrative education. In J. A. Vasquez, L. D. Compeau, & R. Crawford (Eds.), Puppets, people and probots: Using creativity to bring science, technology, engineering, arts, and mathematics to life (pp. 34–44). Harrisonburg: James Madison University.