Makerspaces as educational spaces: an analysis based on an international multiple case study.

Makerspaces como espaços educacionais: uma análise baseada em um estudo de casos múltiplos internacionais

Los makerspaces como espacios educativos: un análisis basado en un estudio de caso múltiple internacional

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Abstract
Objective: the objective of this article is to analyze how makerspaces present themselves as educational spaces, in an international analysis, in five cities.
Methodology/approach: Initially, the article contextualizes the topic and presents the theoretical framework with authors who support the discussion. Next, the methodology that uses a multiple case study, based on data triangulation, is explained. Data processing was developed using Nvivo software, which allowed an analysis of maker culture from the perspective of education and technology.
Originality/relevance: Makerspaces are considered a new form of collaborative workspaces, in which people come together to work on personal and/or collective projects, using traditional and/or technological tools. They are present in important cities such as Lisbon, Barcelona and in Brazil they can now be found in the cities of Curitiba, São Paulo, Recife, among others.
Main conclusions: it is concluded that the social relations that structure makerspaces result from an intertwining of education, technology, social inclusion and creativity.
Contributions to knowledge: the topic investigated contributes to the advancement of knowledge, by presenting a new frontier of research, that is, Makerspaces. It has been demonstrated that educational spaces can present much more consistent results, as they optimize coexistence between system agents.
Executive contributions: the study makes it possible to recommend pragmatic actions to obtain desirable results.

Keywords: Makerspaces. Education. Learning. Technology.

Resumo
Objetivo: objetivo deste artigo é analisar como os makerspaces se apresentam como espaços educativos, numa análise internacional, em cinco cidades.
Metodologia/abordagem: Inicialmente, o artigo contextualiza o tema e apresenta o referencial teórico com autores que sustentam a discussão. A seguir, é explicada a metodologia que utiliza um estudo de casos múltiplos, baseado na triangulação de dados. O processamento dos dados foi desenvolvido por meio do software Nvivo, que permitiu uma análise da cultura maker sob a perspectiva da educação e da tecnologia.
Originalidade/relevância: os Makerspaces são considerados uma nova forma de espaços de trabalho colaborativos, nos quais as pessoas se reúnem para trabalhar em projetos pessoais e/ou coletivos, utilizando ferramentas tradicionais e/ou tecnológicas. Estão presentes em cidades importantes como Lisboa, Barcelona e no Brasil já podem ser encontrados nas cidades de Curitiba, São Paulo, Recife, entre outras.
Principais conclusões: conclui-se que as relações sociais que estruturam os makerspaces resultam de um entrelaçamento de educação, tecnologia, inclusão social e criatividade.
Contribuições para o conhecimento: o tema investigado contribui ao avanço do conhecimento, ao apresentar uma nova fronteira de pesquisas, ou seja os Makerspaces. Demonstrou-se que os espaços educativos podem apresentar resultados muito mais consistentes, na medida em que otimiza o convívio entre os agentes do sistema.
Contribuições executivas: o estudo permite recomendar ações pragmáticas para que se obtenha resultados desejáveis.

Keywords: Makerspaces. Educação. Aprendizagem. Tecnologia.

Resumen

Objetivo: el objetivo de este artículo es analizar cómo los makerspaces se presentan como espacios educativos, en un análisis internacional, en cinco ciudades.
Metodología/enfoque: Inicialmente el artículo contextualiza el tema y presenta el marco teórico con autores que sustentan la discusión. A continuación, se explica la metodología que utiliza un estudio de casos múltiples, basado en la triangulación de datos. El procesamiento de datos se desarrolló utilizando el software Nvivo, que permitió un análisis de la cultura maker desde la perspectiva de la educación y la tecnología.
Originalidad/relevancia: Los Makerspaces se consideran una nueva forma de espacios de trabajo colaborativos, en los que las personas se reúnen para trabajar en proyectos personales y/o colectivos, utilizando herramientas tradicionales y/o tecnológicas. Están presentes en ciudades importantes como Lisboa, Barcelona y en Brasil ahora se pueden encontrar en las ciudades de Curitiba, São Paulo, Recife, entre otras.
Principales conclusiones: se concluye que las relaciones sociales que estructuran los makerspaces resultan de un entrelazamiento de educación, tecnología, inclusión social y creatividad.
Contribuciones al conocimiento: el tema investigado contribuye al avance del conocimiento, al presentar una nueva frontera de investigación, es decir, los Makerspaces. Se ha demostrado que los espacios educativos pueden presentar resultados mucho más consistentes, ya que optimizan la convivencia entre los agentes del sistema.
Contribuciones ejecutivas: el estudio permite recomendar acciones pragmáticas para obtener resultados deseables.

Palabras clave: Espacios Maker. Educación. Aprendizaje. Tecnología.

1 INTRODUCTION

The Constitution of the Federative Republic of Brazil of 1988 made education a subjective public right (Brasil, 1988). Therefore, all citizens have the duty and right to enjoy free, quality public education. Over the years, education has been modified and new ways of accessing different technologies have started to emerge on a recurring basis. In this way, it is not possible to think of a society disjointed from the issues that are intertwined in the field of Science, Technology and Innovation (CT&I) (Burkarter et. al, 2024).

The relationships between Science, Technology and Innovation are always present in people's daily lives. Among the countless places in the city where these relationships occur

and enable the exchange of knowledge, conversation and construction of knowledge, are schools. However, school is not the only space where education is present in people's lives. For Moll (2019), the city represents a large network of formal (schools, universities, institutes) and informal pedagogical spaces (theaters, squares, museums, libraries, media outlets, public offices, churches).

Among the countless spaces that the city offers, it is possible to find makerspaces, or "creation spaces". Common in many cities around the world, with a predominance in developed countries, they have, in recent years, also gained prominence on the national scene (Frosch, 2020). They are found in libraries, museums, schools, universities or in public or private facilities. They are designed with specific goals, such as serving individuals and the communities where they are located and providing a combination of equipment, community, and education to create or design something new (Sharma, 2021).

Makerspaces are a new form of collaborative workspaces and are presented as open places (Niaros et al., 2017), where people meet to work on personal or collective projects, using traditional or technological tools (Sharma, 2021). Makerspaces are creation environments that present digital manufacturing proposals using various tools and equipment that provide "do it yourself" actions (Silva and Souza, 2020).

In this context, it is necessary to analyze makerspaces from cities, with their interactions with spaces, people, technology and all other actors involved in the process. The objective of this article is to analyze how makerspaces constitute educational spaces in the cities of Curitiba, São Paulo and Florianópolis. Lisbon and Barcelona.

Makerspaces have recently been structured in Brazilian cities, with less than 20 years of existence (Frosch, 2020; Campos et al., 2018). As a result, research on the topic is still incipient (Campos et al., 2018). Despite the increase observed in the number of publications in recent years on the topic, discussions about makerspaces as educational spaces are still necessary. In this article we chose to use the term makerspaces, considering that it is also used in the two cities in Europe, which were part of the study.

2 THEORETICAL FRAMEWORK

Sharma (2021), in his studies, emphasizes the need for academics to undertake research efforts concerning makerspaces in the context of developing regions of the world. In research carried out by Braz (2019), the author suggests the need to continue studies related to makerspaces in formal and informal education environments, given that this topic is still little studied (Braz, 2019).

To better understand the concept of makerspaces, it is necessary to understand how these spaces emerged. Makerspaces arise from the popularization of the maker movement, which originated in the United States of America with the publication of Make Magazine, made by Dale Dougherty in 2005 (Sang; Simpson, 2019; Anderson, 2012). became popular in 2011, when Dale Dougherty and Make Magazine registered the term makerspace and began using it to refer to places accessible to the public to design and create (Cavalcanti, 2013). Since then, the maker movement has been growing stronger all over the world (Aleixo; Silva; Ramos, 2021).

The first formal maker environments emerged in American technology colleges, such as the Center for Bits and Atoms, at the Massachusetts Institute Technology (MIT) in 2001. Professor Neil Gershenfeld created a pedagogical environment in which he allowed people to solve problems using the DiY methodology (Do it yourself) with the use of various tools, both high and low cost. In this way, the first collaborative spaces emerged (Niaros et al., 2017). Since then, a digital manufacturing network has been gaining more and more strength and notoriety in several countries.

The maker movement is based on the “do it yourself” principle, encouraging ordinary people to build, repair, modify, adapt and manufacture, with their own hands/tools, the most diverse types of objects and projects of their interest (Anderson, 2012; From this movement, a new culture was established, the maker culture. For Fressoli (2015), maker culture constitutes a contemporary-based innovation movement, the impacts of which are still unknown in many countries, especially in less developed ones.

The observation that maker culture is based on the concept that "you learn by doing" allows us to infer a convergence of this concept with the ideas popularized by Freire (1997), Papert (2008) and Moran (2018).

2.1 Constitution of makerspaces

Maker environments typically consist of a mix of low- and high-tech equipment. Low-tech equipment includes: soldering iron, saws, drill, pliers, screwdrivers, hot glue gun, sandpaper and others. As for the more technological tools, the most common are: 3D printer, laser cutter, CNC machines, milling machines and robotics equipment (with Arduino and Raspberry Pi) and free software to create/recreate products (Santos; Andrade, 2020; Webb, 2018).

Although there are some convergences between makerspaces, hackerspaces and Fab Labs, each space has its own characteristics. It is worth noting that not every makerspace is a Fab Lab, but every Fab Lab is also a makerspace (Frosch, 2020). Among the particularities of these are the use of certain digital manufacturing machines. In this sense, maker environments come in three distinct concepts: makerspaces, hackerspaces and Fab Lab (Silva; Souza, 2020; Van Holm, 2014).

2.2 Types of makerspaces

It is possible to differentiate maker environments according to their proposals. According to Silva and Souza (2020), each environment has a certain proposal, with different spaces and specific projects. Makerspaces are easily divided into three types. Hackerspaces focus especially on electronics and programming, while makerspaces are maker environments that present digital manufacturing proposals using various tools and equipment that provide "do it yourself" actions. However, Fab Labs are makerspaces that have different operating rules than others (Silva; Souza, 2020, p. 6).

For Tan (2019), makerspaces are perceived as future spaces for innovation. Maker environments also bring together tangible and intangible knowledge in the same space.

For Van Holm (2014), the three concepts have different origins. Makerspaces and hackerspaces are more focused on openness, sharing and joint learning and tend to be independent spaces. Fab Labs are linked to the rules and regulations of a given foundation (Fab Foundation, 2021)

3 METHODOLOGY

Regarding its nature, research can be classified as “applied”, since it aims to produce knowledge for the practical solution of a specific problem (Gil, 2010) with an exploratory and descriptive purpose (Gil, 2010; Markoni; Lakatos , 2010). The research is characterized by presenting in its general objective the description and verification of the existence of associations and the establishment of relationships between variables (Gil, 2010).

Regarding the approach, this is predominantly qualitative research (GIL, 2010) as it considers the existence of a dynamic relationship between the real world and the subject (Silva; Menezes, 2005). Qualitative research seeks to describe and understand a phenomenon. Therefore, its objective is not generalization, but the understanding of the event and the possibility of comparison with situations in similar contexts (Ollaik; Ziller, 2012).

Qualitative analysis is less formal, and can be developed through a sequence of activities that involve data reduction, categorization, interpretation and writing of the report (Gil, 2010). In this approach, multiple, socially constructed realities are admitted, producing different meanings, from the perspective of each research participant, including having the researcher influence the research through their own principles (Lüdke; André, 1986).

Regarding the selection of the research method, the multiple case study was adopted, to achieve an understanding of a contemporary event, in the identification and description of relevant variables on the topic, in addition to characterizing the dynamics of the relationships between them (Yin, 2001). During the development of a study, it is also common to adopt a sequence of different research methods, to meet the specific objectives outlined (Santos, 2018).

Although the main research method is the multiple case study, strategies involving the combination of other methods will be adopted. To ensure reliability and internal validation of

case interpretation, the method is based on multiple sources of evidence, to allow triangulation or convergence at the end of the analysis (Yin, 2001).

To collect secondary data, the bibliographic collection technique and systematic literature review procedure were used to understand the state of the art on the topic covered (Treinta et al., 2013). Primary data collection was also carried out, based on semi-structured interviews with policymakers and makerspace managers.

To define the strategies for collecting and analyzing this data, a research protocol was developed, which detailed all the variables to be considered (Yin, 2001). After the interviews, data analyzes were carried out using deductive analysis (Gil, 2010), supported by the use of NVivo software.

We chose to analyze the cases of five cities, defining a specific context, delimited by the specific choice of the cities of Curitiba (PR), São Paulo (SP), Florianópolis (SC), Barcelona (Spain) and Lisbon (Portugal). The choice of cities was based on the following aspects:

- Curitiba, capital of Paraná, internationally recognized as an innovative city; Over the last few years, he has won relevant awards on the national and international scene. Since 2017, the city has been reformulating the public libraries of municipal schools, adding a maker space to them (Prefeitura Municipal de Curitiba, 2018). Another decisive factor in this choice is related to the fact that the city opened a public Fab Lab "Lab Fab Cajuru" in 2019 (Prefeitura Municipal de Curitiba, 2019).
- São Paulo, the largest city in Latin America, capital of the state of São Paulo. Another criterion is linked to the fact that the city has the largest public network of Fab Labs in the world, spread throughout the city (Frosch, 2020).
- Florianópolis, capital of the state of Santa Catarina. The city has invested in knowledge actors and public actors in the city's innovation ecosystem (Teixeira et al., 2016). Another decisive factor for your choice is the educational proposal of the cities in Santa Catarina. In 2017, the SESI (Industry Social Service) Maker Blumenau Education Space was opened - the first maker space in Santa Catarina, in the city of Blumenau. Currently, the educational proposal through the makerspace is already

present in other cities in the state of Santa Catarina, including Florianópolis (Prefeitura Municipal de Florianópolis, 2021).

- Barcelona: Capital of the Catalonia region in Spain. It occupies a prominent place in public policies aimed at education, innovation and technology. Another relevant aspect for this choice refers to the impulse that the city has experienced since 2014 with the creation of a network of manufacturing spaces in city neighborhoods (Paio, 2021).
- Lisbon: Capital of Portugal. It is among the main cities in Europe to promote the dissemination of creative and innovative businesses, a process accompanied by a series of public and private investments and intervention programs (Portellada, 2019).

The interviews were carried out in a virtual format (online platform) using the Google Meet platform or another platform indicated by the interviewee. There was no physical contact between the researcher and the interviewees, considering that the interviews took place during the COVID19 pandemic and the difficulty imposed by the distance between the five chosen cities. The interviews lasted on average between 40 and 60 minutes, scheduled in advance, according to the availability of both participants and the researcher.

The interviews were carried out with professionals who fit the profile of the target audience targeted by the research (being a policymaker and a makerspace manager in each city analyzed).

4 DATA ANALYSIS

As a methodological procedure, we opted for the deductive content analysis proposed by Gil (2010). The analysis will follow the paths outlined by Gil (2010) in the process of inductive content analysis, in addition to the use of NVivo software to assist in the analysis of the data obtained. The analysis of the collected data was based on the theoretical framework and the assumptions listed. Content Analysis is also a mixed method, involving a quantitative and qualitative approach.

Data validation occurred using the data triangulation technique (Yin, 2001). The data provided by the interviewees were crossed with those obtained through the theoretical

framework studied. Triangulation is necessary so that we can return to the objective of analyzing how makerspaces present themselves as educational spaces, in an international analysis, in the cities of Curitiba, São Paulo, Florianópolis. Lisbon and Barcelona.

The theoretical framework presents makerspaces as spaces for socialization, experimentation, leisure, learning, but also for social actions and entrepreneurship (Costa; Pelegrini, 2017). For this study, public makerspaces in the cities analyzed were mapped. Private and university spaces were not included due to the scope of the investigation.

Below, an overview will be presented describing how the cities analyzed had public makerspaces in the year 2022, the period in which the study was carried out.

4.1 Public makerspaces in the city of São Paulo (SP)

During the period in which the mapping was carried out, it was found that the largest network of public makerspaces was in the city of São Paulo. The Fab Lab Livre SP Network is currently the largest network of public digital manufacturing laboratories in the world, with completely free spaces in which citizens have free access, through cutting-edge technology, to develop ideas and projects.

By 2022, the city had 13 units located throughout the city that offered more than 30 types of courses and workshops, such as 3D modeling, electronics and project manufacturing. These units had advanced equipment, such as 3D printers, milling machines and laser cutters (Prefeitura Municipal de São Paulo, 2022). Some of these spaces were also located in some municipal schools in the city.

São Paulo also had other spaces that offer digital manufacturing workshops, coworking, living labs, but these are offered in private spaces. Many of these spaces are linked to the Fab Foundation, while others are independent. The public makerspaces in the city of São Paulo are also linked to the Fab Foundation, both the equipment from the Fab Lab Livre SP Network and the Fab Lab SP – Laboratory of Models and Tests – LAME FAU USP (University of São Paulo).

4.2 Public makerspaces in the city of Curitiba (PR)

Another city that has promoted the inclusion of public makerspaces in the city is Curitiba. One of its public makerspaces is the Curitiba Fab LabUnidade Cajuru, linked to the Fab Foundation. It is the first public Fab Lab in the city, opened in March 2019 on Rua da Cidadania do Cajuru. The space functions as a digital manufacturing and prototyping laboratory where students, companies and the community can share knowledge and put innovative projects and ideas into practice.

The prototyping machines are available to the population with the support of instructors who provide guidance on the use of the equipment and its application. The laboratory has a large space for machines and workstations and a meeting room, with the following equipment: 3D printers, laser cutting and engraving equipment, CNC router, bench milling machine, cutting plotter, electronic equipment (oscilloscope, function generator, adjustable source, soldering station) and tools in general (Curitiba Fab Lab, 2022).

Another public policy that expanded makerspaces in the city of Curitiba was the reorganization of some school libraries. Thirty-four school libraries had their own space called Farol do Saber, which functioned as a library for students, teachers, the school community and the community in general (Curitiba, 2018). In these spaces there were also computers with Internet access available.

From 2017 onwards, these spaces began to be restructured and came to be called Farol do Saber e Inovação (Curitiba, 2018), offering, in addition to library and computer services with internet access, 3D printers, a Maker space, the which favors learning experiences, the development of creativity and innovation processes (Curitiba, 2020). Currently these spaces can be found in different regions of the city.

For Oliveira, Bastos and Labiak, Jr. (2021), the Lighthouse of Knowledge and Innovation allows students, teachers and the community in general to have access to a vast literary collection in the neighborhood itself, in addition to enabling the use of technological devices, encouraging dialogue and exchange of information. The neighborhood also has public facilities that strengthen social and cultural relations and provide opportunities for knowledge, valuing the space and local knowledge (Oliveira; Bastos; Labiak Jr., 2021, p.

1193). In this way, when inserting the makerspace in the Lighthouses of Knowledge and Innovation, it can be said that they function as public makerspaces.

4.3 Public makerspaces in the city of Florianópolis (SC)

The city of Florianópolis, in turn, stands out for its high concentration of actors linked to science, technology and innovation (Prefeitura Municipal de Florianópolis, 2022). In the mapping carried out in 2022, it was possible to observe that the city only had two public makerspaces in the city, and both are linked to the Federal University of Santa Catarina (UFSC).

Both Pronto 3D (Pronto 3D) and Via Maker (UFSC, 2022) are considered makerspaces, and are linked to UFSC. These are digital manufacturing spaces open to students, the academic and non-academic community. Pronto 3D is used by undergraduate students in Design, Product Design and Architecture, in addition to offering extension activities for students in elementary schools. The Pronto3D Network is also present in other cities in Santa Catarina (Federal University of Santa Catarina, 2022).

4.4 Public makerspaces in the cities of Barcelona (Spain) and Lisbon (Portugal).

In the city of Barcelona, until 2022, residents had five public makerspaces, a network called Ateneu de Fabricació, spaces located in different districts of the city. Each one has its own identity based on the specific area of activity of the projects developed. They are: Les Cortes Fab Lab; Fab Laboratory at Fábrica Del Sol; Ciutat Merediana Fab Lab; Fab Laboratory of the Nou Barris Technological Park and Gràcia Fab Lab (Ajuntament Barcelona, 2022).

These spaces offer a public service that disseminates the technology and science of digital manufacturing. They are places to learn and collaborate on different projects. Anyone can take advantage of the public tools and resources available (Ajuntament Barcelona, 2022.

Lisbon has been investing for some years in promoting various projects, not only as a promoter of innovation, but also as a mediator between all the city's actors – Universities, companies, State and citizens – and in collaborative innovation projects. The existence of a

very diverse entrepreneurial ecosystem in the city (incubators, startups, accelerators, companies, Fab Labs and creative hubs) has strongly contributed to an atmosphere of constant innovation (Lisbon, 2022).

The city of Lisbon has spaces that promote innovation, such as: Mouraria Innovation Center, Hub Criativo do Beato, Mercado Ofícios and Mercado do Bairro Alto. However, the city had a single public makerspace, Fab Lab Lisboa. This is a space for digital manufacturing and prototyping, where the main objective is to transform ideas into reality, allowing the creation of new products that, in turn, can be transformed into value, employment and wealth generated in the city and the country (Lisbon, 2022).

4.5 Analysis of public Makerspaces in cities

After carrying out this mapping, it is concluded that all the cities analyzed have public makerspaces, in greater or lesser numbers. This highlights the concern of municipal managers in implementing a public policy focused on innovation. These spaces aim to promote the use of cutting-edge technological devices, such as: 3D printers, milling machines, laser cutting and engraving equipment, encouraging the “do it yourself” culture. Another fact analyzed refers to the geographic issue of makerspaces. In the cities of Barcelona, Curitiba and São Paulo, it was observed that these spaces are located in different regions of the city.

After carrying out the previous mapping, it is necessary to take a look at the interrelationship between these spaces, the cities considered and the respective educational proposals.

5 FINAL CONSIDERATIONS

Below is a summary resulting from the analysis of previously described data.

5.1 Makerspaces and the dialogue with education

Literature has shown that the most common spaces for makerspaces and Fab Labs are found in schools, libraries, museums and Universities (Costa; Pelegrini, 2017, Pedrinho et al., 2020). This occurs with the insertion of education in an information society (Castells, 2000), in which citizens must be protagonists of their own learning. To achieve this, digital technologies must be used to promote meaningful and deep learning, capable of instigating

curiosity, creativity and providing moments of reflection about the world in which they live (Aleixo; Silva; Ramos, 2021).

In the educational sphere, maker culture has increasingly aroused the interest of students, educators and educational institutions, from basic education to higher education. Due to the possibility of associating theoretical curricular contents with explicit practices, making the student the protagonist of the construction of their knowledge (Aleixo; Silva; Ramos, 2021). Furthermore, maker culture and the dissemination of new digital manufacturing technologies can engender new scenarios for education, research and the development, production and distribution of products (Costa; Pelegrini, 2017). In schools, the dissemination of maker culture encourages project-based learning in areas such as: robotics, design, programming and engineering, developing new capabilities and skills (Costa; Pelegrini, 2017).

In Brazil, makerspaces or Fab Labs are strongly linked to Universities, Research Centers, Higher Education Institutions and Departments of Science, Technology and Innovation (Costa; Pelegrini, 2017). The authors also mapped these spaces in private educational institutions and also in Public Universities such as the University of São Paulo, Unicamp, Federal University of Bahia, Federal University of Rio de Janeiro and the Federal University of Santa Catarina.

Digital manufacturing research groups within Universities have the potential to develop methods and processes, enabling the development of important innovations for the country (Costa; Pelegrini, 2017). This perception corroborates that of Markkula and Kune (2015), who indicate that universities add value to regional development processes, anchoring the importance of knowledge in the innovation ecosystem. For Monfredini and Frosch (2020), the makerspaces of Brazilian universities are still linked to teaching objectives, to the detriment of the real possibilities for articulating the university with society.

Makerspaces and/or Fab Labs inserted in Universities can promote interaction between researchers, students and society, opening new dimensions for science and education, inspiring curiosity and providing new ways for the development of ideas with a certain impact (Costa; Pelegrini, 2017; Monfredini; Frosch, 2020). However, those who benefit most from

these spaces at universities are still students and professionals linked to the areas of engineering, architecture, design, computing and arts (Frosch, 2020).

Despite the growing number of publications that address the topic of makerspaces and Fab Labs within universities (Sharma, 2021), a new field has attracted the attention of researchers and academics, to the use of libraries as makerspaces or Fab Labs.

Santos and Candido (2019) found that there is not much data on makerspaces in libraries in Brazil. However, libraries are consolidating themselves as a new space, based on the inclusion of the maker movement in the educational field.

Many institutions such as schools, libraries and museums have created different spaces for learning, the so-called maker spaces, which are innovative environments for children, young people and adults to invent, plan and build through collaborative work (Prefeitura Municipal de Curitiba, 2018).

The use of libraries as makerspaces has been a policy developed by public managers as a strategy for bringing users closer together and maintaining them by enabling the development of projects that stimulate creativity, innovation and that empower people to experiment and use different technologies for implementation of their ideas, developing some skills (Prefeitura Municipal de Curitiba, 2018).

The use of libraries as makerspaces has been a policy developed by public managers as a strategy for bringing users closer together and maintaining them by enabling the development of projects that stimulate creativity, innovation and that empower people to experiment and use different technologies for implementation of their ideas, developing some skills (Prefeitura Municipal de Curitiba, 2018).

It is worth reiterating that the conception of culture and the maker movement is based on the premise of “do it yourself”, and is aligned with important names in the educational field, such as Paulo Freire and Seymont Papert (Freire, 1997; Papert, 2008; Moran, 2018). These theorists point out paths that can distance the passive reproduction of knowledge (Aleixo; Silva; Ramos, 2021). Thus, maker culture can make a decisive contribution, since deeper learning proposes spaces and practices of “doing”, environments that are significant in opportunities and creation (Moran, 2018) and the best way to learn is to be actively involved

in making something, through hands-on activities, a position that is in accordance with constructionist learning theories (Papert, 2008).

It can be said that one of the precursors of this pedagogical movement that today aligns itself with culture and the maker movement, is Dewey, who since the 1910s, expounded on the importance of experimentation, of providing joint practices, promoting situations of cooperation between children and carrying out “hands-on” activities to enable the development of learning. For Vygotsky (1978), the importance of social interaction in the teaching and learning process, valuing collective and collaborative work, also promotes learning.

Considered one of the main educators in Brazil, Paulo Freire (1997) defended the development of pedagogical practices that stimulate people's curiosity, active stance, experimentation and autonomy. In one of his classic works, Pedagogy of Autonomy, Freire (1996) points to a concept of education for all based on the principle of emancipation, through a practice of liberation. According to the author, “teaching is not transferring knowledge, but creating educational possibilities, in an emancipating context, for its production or construction” (Freire, 1997, p. 14).

Therefore, based on this line of emancipatory education, in which individuals learn by socializing their knowledge, being the protagonist of their learning process, makerspaces and the Fab Lab are essential spaces for education, especially non-formal education. From the moment these spaces are occupied by people with different interests, ages and academic and life experiences, synergy between people happens, strengthening creative processes, promoting a new learning movement.

5.2 Makerspaces as educational spaces

The propositions presented by Cavalcanti (2013) and Maravilhas and Martins (2016) are in line with the perceptions of all interviewees when they treat makerspaces as a space conducive to sharing ideas and exchanging experiences. This finding brings an important element when investigating the articulation of makerspaces as educational spaces, however it is not the only one.

When the interviewees were questioned, the interviewees also pointed out that it is necessary Before delving into this topic, it is necessary to define the angle from which education is conceived in this article. The approach adopted here considers an education based on the centrality of the individual as the protagonist of learning, based on the relationships they have with the world and society, based on authors such as Freire (1991; 1997; 2001).

Gadotti (2006) and Papert (2008). Education is understood here as a process that is not limited to school education, but is present throughout a human being's life, supported by Freire's conception (2001):

Learning and teaching are part of human, historical and social existence, as are creation, invention, language, love, hate, astonishment, fear, desire, attraction to risk, faith, doubt, curiosity, art, magic, science, technology. And teaching and learning by cutting out all these human activities (Freire, 2001, p. 24).

If makerspaces are configured as an educational space, they were unanimous in responding affirmatively, justifying their answers. For them, this happens because these are spaces conducive to sharing ideas, interaction and exchanging knowledge. It should be noted that makerspaces are educational spaces different from the classroom, where users learn through experimentation and collaborative integration, supported by the “do it yourself” culture.

Learn to use the digital tools that the space offers. All statements reinforce the idea that users learn “something” when using the space, and as a result of this learning, makerspaces become educational spaces.

6 CONCLUSIONS

By aggregating all the responses from the interviews and analyzing them, it was possible to identify that the main element that configures makerspaces as educational spaces is learning. In this analysis, it is clear that learning is linked to:

• Technology: Learning how to use available technological resources;

• Social interaction: Learning in social interaction, with the exchange of knowledge between users;

• Maker culture: Individual learning resulting from the “do it yourself” idea, supported by experimentation.

This learning is perceived both in the literature and in the statements of the interviewees. In Brazil, makerspaces are strongly linked to Universities (Pedrinho et al., 2020). Three Federal Universities make the use of their makerspaces available to students on certain courses and offer community outreach activities. This corroborates the statements by Monfredini and Frosch (2020), when stating that these spaces are still linked to teaching objectives, to the detriment of the real possibilities of articulation between the Brazilian university and society.

It is also possible to conclude that the analyzed makerspaces belonging to Universities are strongly linked to certain courses in the exact sciences and social sciences applied to certain courses, such as engineering, architecture and design, as already found by Costa and Pelegrini (2017).

Given the data analyzed, it is possible to affirm that learning is the crucial point of makerspaces. It appears that 100% of those interviewed believe that makerspaces are spaces for learning and exchanging experience.

This learning is directly linked to technology, social interactions and maker culture, which are not presented in a sealed manner, but are linked to each other and are based on learning, as illustrated in figure 1.

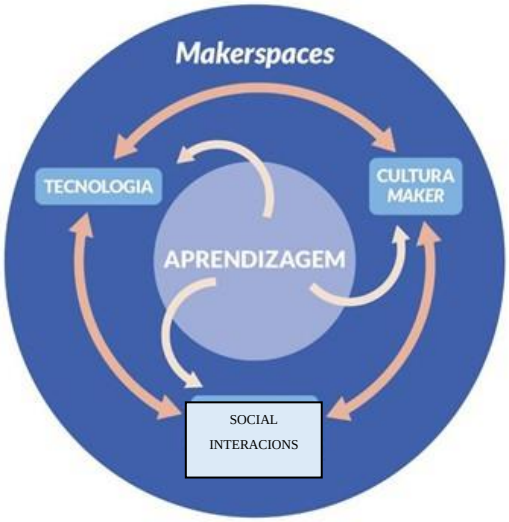

Figure 1: Learning in makerspaces
Source: Own authorship (2022).

In this way, it is possible to affirm that education can happen outside school spaces, in non-formal spaces, as attested by Gadotti (2010) and Alceu and Brandenburg (2018). However, for education to take place in all spaces of the city, it is necessary for local public policies to link education to different actors (Alves; Brandenburg, 2018; Moll, 2019) aiming at the social, cultural and educational development of all its inhabitants, and consequently the strengthening of the territory.

Furthermore, another unique contribution of makerspaces is linked to ST&I issues. Considering that these spaces behave as part of a complex educational ecosystem, this articulation between ST&I and education should not be seen in an isolated and isolated manner; they must be articulated to other actors involved directly and indirectly with education (Burkarter, et.al, 2024).

The analyzes and discussions discussed here sought to highlight the role of makerspaces in cities, their interactions with spaces, people, technology and the actors involved in this process. The objective proposed in this article is to analyze how makerspaces present themselves as educational spaces, in an international analysis, in five cities.

The article mapped the main public makerspaces in the cities analyzed. This mapping was carried out in the cities of Curitiba, Florianópolis, São Paulo, Barcelona and Lisbon through searches carried out on the internet, in the year 2022. It was possible to verify that the five cities analyzed offer their citizens public creative spaces and that Brazilian cities also have makerspaces; some of them have invested in public policies that allow the population to use these spaces. Furthermore, it was found that they were gaining more and more prominence in cities, and currently represent relevant spaces.

Another highlight is the connection between makerspaces and education. It can be seen that these spaces present a dialogue with education, formal and informal, and also function as educational spaces.

Makerspaces are common places in Universities, especially in Brazil. These are spaces that should encourage innovation, entrepreneurship and the exchange of knowledge. However, in most institutions, these spaces are still reserved exclusively for university students, especially a select group with certain degrees.

It is concluded that learning is a crucial point of makerspaces, based on issues of technology, social interactions and maker culture, constituting them as educational spaces.

It is possible to affirm that the contributions of these spaces are directly linked to issues related to education, technology, digital inclusion, entrepreneurship, income generation and creativity, based on maker culture and cities.

All research is linked to the researcher's perspective, based on their theoretical and personal conceptions, linked to a certain geographic, social, cultural and temporal context. Therefore, this study also had limitations. One of these was linked to the search for makerspaces. For this, data available on websites, scientific articles and open access documents on the internet were used. An on-site research in these spaces would be interesting, to better understand the organizations and dynamics specific to each space.

Based on all the contributions arising from this study, it is suggested to extend the research to an investigation into the users of makerspaces. It would be valuable to understand the motivations of the people who use these spaces and their perceptions about them, expanding listening and expanding results.

In view of the analyses, it is possible to conclude that makerspaces can be considered as integral spaces of cities, which play a relevant role in the construction of knowledge, whether formal or informal. That learning in these spaces is based on three topics: Technology, social interactions and maker culture supported by experimentation and the materialization of ideas. In this way, these spaces are consolidated as spaces for education and learning and must be available to everyone in cities.

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