Journal of Systemics, Cybernetics and Informatics (2023) 21(3), 23-28
https://doi.org/10.54808/JSCI.21.03.23

A new digital culture in Architecture and Engineering design classes with technological advances

Mozart Joaquim Magalhães VIDIGAL
Architecture School, Universidade Federal de Minas Gerais
Belo Horizonte, Minas Gerais, Brasil
email: mozartvidigal@gmail.com

Renata Maria Abrantes BARACHO
Architecture School, Universidade Federal de Minas Gerais
Belo Horizonte, Minas Gerais, Brasil
email: renatambaracho@gmail.com

Marcelo Franco PORTO
Engineering School, Universidade Federal de Minas Gerais
Belo Horizonte, Minas Gerais, Brasil
email: marcelofrancoporto@gmail.com

ABSTRACT

This work deals with the approach of information and communication technologies in the classroom activities of the disciplines of architectural projects to propose improvements in the formation of architects and in the teaching models practiced in schools of Architecture and Engineering of Belo Horizonte, Minas Gerais, Brazil. The objective of this work is to discuss the use of technology through the design course. The position of Professors in the adoption of these technologies was analyzed. The work presents an analysis of pedagogical practices to reflect on possible advances, disharmonies and conflicts with the use of technologies in design development. This discussion can contribute to stimulating the qualification of Professors and future professionals. The findings indicate that new pedagogical practices with the use of technology can be gradually adopted. So Professors and students can better interact and develop the teaching/learning relationship with the updated models of teaching architectural projects. [1]

Keywords: Information and Communication Technologies, ICTs, design studio classroom, digital culture.

1. INTRODUCTION

Technology has been one of the solutions to overcome the educational challenges of a country like Brazil, with large extensions and needs for transformations. In the culture and history of a society, one can identify the importance of the role of teachers and those who are directly involved with education. Education is considered one of the most significant forms of power to positively interfere with people's development and their transformation into society's modifying agents. This principle of the educational process preserves the dynamism of building groups capable of promoting reflection on the needs and expectations of citizens, government officials, and their public policies.

In recent decades, the new Information and Communication Technologies (ICTs) have been presenting new ways of interacting, managing and disseminating information. New ways of thinking, new attributes for carrying out activities stimulate the improvement of the quality of the educational system.

Many schools are thinking about new themes and bringing reflections to their learning environment. The search for information to bring teachers and students closer together in a less formal relationship has been done. A mediator and stimulator of criticism, who collaborates with the construction of knowledge, will replace that teacher, supposedly the holder of knowledge. Training spaces were forced to keep up with this new pace of information. New themes, rethinking the physical space, the layout in order to favor learning should be encouraged. The current teaching environment must follow the trend, allowing students to work and share their experiences with each other and with their teachers, experimenting, stimulating, creating and building their knowledge.

The availability of technological resources for learning architectural skills remains limited. These spaces accommodated both educators and students, who engaged in experimental and intricate teaching methods. As technology advanced, teaching methodologies shifted from being potential learning opportunities to actual lived experiences. This evolution not only entailed the adoption of sophisticated technologies but also contributed to behavioral changes. Certain countries, such as Brazil, continue to grapple with fundamental challenges in integrating technology. For instance, the Integrated Student Project, conceptualized and introduced in 2016, centered on education and the utilization of technology to enhance the world, aiming to explore diverse perspectives throughout all educational levels. This initiative highlighted the imperative to establish tangible and virtual platforms for training primary school pupils within the Brazilian public education system, imparting proficiency in information and communication technologies (ICTs)[1]. Simultaneously, universities are rapidly and extensively expanding their technological infrastructure, while the nation invests in broadening the integration of technology in primary education.

[1]We would like to express our deep gratitude to Professor José Ricardo Queiroz Franco and Professor Mário Lúcio Pereira Júnior for their comprehensive and detailed reviews of this document, as well as for their suggestions that improved the final version.

The most critical period of the COVID-19 pandemic was marked by several transformations in society. This topic is too broad to be treated in all its breadth, but a consequence of this period was the acceleration of the process of computerization and development of ICTs, in several sectors and mainly in aspects related to education.

Students in a design class, motivated by technology and its advances, face the challenge of learning and sharing knowledge with each other and understanding changes. The rapid evolution of software and the need to adapt to the new reality forces professionals to change their reasoning and procedures to develop architectural design. The reasoning changes because the origin of the project is no longer a point on paper, but three-dimensional coordinates on the computer. Procedures change as graffiti and manual labor are replaced by computer interface and devices.

The use of these technologies in civil construction and in the training of Engineers and Architects requires profound changes in the production of the architectural object. Design is transferred from manual labor to 2D CAD software, from 2D software to 3D, and then to Building Information Modeling (BIM) technology. The use of the BIM methodology as a teaching/learning tool and its application in building projects covers three important areas: diffusion of information technology, new possibilities of representation and simulation of architecture and construction, and new paradigms of formal education [2]. The BIM methodology is one of the most promising developments in the architecture, engineering and construction industry. The three-dimensional virtual model of a building incorporates relevant and necessary information for the stages of a building's life cycle: design, manufacture, construction and operation. Technology integrates architects, engineers and builders, changing and streamlining the information cycle, being an evolution that allows new possibilities for visualization, processing, representation, use and retrieval of information. [2], [3]. BIM represents an evolution of graphic applications for the generation of technical drawings (CAD) [4]. Characteristics and recommendations for the implementation and better use of the BIM methodology are widely discussed in works [5], [6], [7], [8].

This work presents arguments to stimulate new reflections and enable the improvement of the practice of teaching and learning in architecture design classes.

2. TEACH AND LEARN

In this scenario, new ways of teaching and learning have been taking shape, reconciling face-to-face activities with distance activities with digital information technology. This changing trend is defined as a hybrid teaching and learning modality [9].

A hybrid environment shares virtual and real-world elements, exploring languages in a computerized environment that allow the integration of these places in the physical and virtual planes. These communication spaces, through computing networks, are defined in cybernetics as immaterial and go far beyond the limits of physical space. Currently, there is a need to propose this type of environments for quality learning, where physical spaces and teaching practices walk with an architecture that is also hybrid [10].

The learning space in a traditional face-to-face environment needs to be redefined. The new classroom loses its character as an orthodox space for an environment where the cycle of activities is always with more quality. Professors and students will spend less face-to-face time together, but will share more quality organized learning activities schedules, where the exchange of experiences will take place in a more flexible environment.

In this phase of acceleration in the use of technology, it is clear that the schools of Architecture and Urbanism and Engineering are not managing to keep up with this transition e. Most of the time, they are not prepared either physically or pedagogically. Learning spaces need adaptation to allow a good performance of physical and imaginary actions carried out by Professors and students. These changes will also allow for imaginary relationships and meanings between activities and the physical environment [11].

The discussion about the function in the teaching and learning environment has been the subject of reflections and studies. Authors highlight the enormous distance between designers, architects and pedagogues in defining needs. Although it is unclear whether the relationship of using this technology to teach architectural design may still be in its infancy. In countries where technology is little applied, the use of manual drawing is noticed. Another factor that can postpone the use of technological tools is the lack of adequate equipment available to students and teachers at affordable prices. Demonstrating these issues will be a major challenge.

The ways of designing considering teaching methodologies, since the modernist movement, is a standardization of school buildings in response to an architectural ideal. It was also found that school buildings do not correspond to the functions for which they are intended [12].

Today's classroom, as a place for building knowledge, must be technically rigorous, comfortable and have good acoustics with technology. It needs to guarantee good spaces for research and projects, allow communication through online technology, reconciling the quality of face-to-face teaching with virtual teaching simultaneously [13].

Classrooms where advanced technologies were inserted in order to verify the level of interference of these environments in the students' learning mode were analyzed [14]. It was found that technology changes study environments. The technological environment of the classroom, due to its complexity, requires better understanding, planning and preparation to meet the wishes of students, teachers and other characters involved in the educational process. This increases the responsibility of design professionals, who need specific knowledge and qualifications in the areas of design, technology and education. Classroom design can affect the relationship between students and staff, influencing the self-esteem of these characters when interacting in these environments. A challenge to investigate a better use of new technologies in teaching and learning has emerged. When it comes to an architecture design classroom, the location must be prepared for a new way of teaching and learning to design. There must be a mix between the traditional teaching of architectural design with the use of clipboards, audiovisuals, digitizing tables and individual computers, associated with the use of new technologies and internet access. For some authors, it is important to try to understand how architecture schools should commit to teaching using digital tools [15].

During the last few decades, the process of transition from architectural design executed in a manual process to the use of computer-aided design (CAD) has been experienced. New technologies that allow the integrated work between geometric model and information have emerged. Several platforms have more advanced ways of developing projects, which allow collaborative work, interoperability, the use of databases and intelligent objects, and more user-friendly interfaces. The BIM methodology has been applied to replace conventional computer-aided design (CAD) methods. Among the advances of this change, we can highlight the three-dimensional simulation of the environment based on computer graphics methods and technologies, immersion in virtual environments with virtual reality, augmented reality, and the use of glasses and other devices with sensors for total immersion in the virtual environment. [16]

Professors should train and encourage the use of new information and communication technologies in the design process. Students can seek new possibilities in the design process, often unfeasible with traditional tools. This highlights the need to review and adapt classroom environments, combined with a change in teachers' attitudes towards the use of new technologies. This new panorama indicates that new ways of working for architects and urban planners are being demanded with the insertion of technology. The influence and changes of this new reality in architecture schools, in teachers and students and in pedagogical plans must be studied. Technologies invade the lives of human beings, expand innovative possibilities and can modify human behavior.

Environments in general are changing due to the introduction of new information and communication technologies, which permeate people's daily lives. We are studying architecture and engineering students, young people who are born in this technological context, connected and integrated via the internet from mobile devices. It can be said that the members of generation Z are young people born from the 1990s onwards and their world has always been connected to the internet, through e-mail, cell phones and all the new media that emerge from the information age [17]. These young people are finishing elementary school and entering university or the job market [18]. For Generation Z, living without the internet, computers and cell phones is inconceivable. Generation Z has broad access to information and is proactive in digital media. On the other hand, the adults of Generation X are those born from the 1960s onwards, inserted in the labor market, people who knowledge and expertise on matters have related to their areas of activity. In general, many deal with the same context of technologies, but in a different way, where they seek to insert and adapt, as they dominate the content of their own qualifications, but with little familiarity and skill in using new technologies.

Technology can also be seen as an element of socialization and innovation, which needs to be informed, taught and learned, as it will be incorporated into the human universe, expanding its knowledge and making it more qualified [19,20].

3. METODOLOGY

This research uses the Design Science Research (DSR) methodology. DSR is an approach that aims to create innovative solutions to complex problems by combining design principles and inductive scientific methods, allowing collaborative. In this study, the research aims to understand issues related to the integration of new information and communication technologies in architecture teaching, observation of phenomena according to the perspective of participants in the school, preliminary analysis with data exploration and interpretation of facts (Figure 01). In the methodology, questionnaires were applied to students and Professors, in addition to an analysis of the infrastructure and software used at the school.

The research began with a survey of MEC data to learn about the guidelines established for architecture schools, followed by an analysis of the teaching of architectural design in the classroom assisted by information and communication technologies. Then, an analysis of the pedagogical project, the curriculum and the educational method of this school was also carried out.

It is exploratory quality-quantitative research, with observation in the classroom and the application of a questionnaire. In this method, descriptive data are obtained through direct and interactive contact between the researcher and the situation under study. In this type of research, it is frequent that the researcher tries to understand the phenomena, according to the perspective of the participants of the studied situation and, from there, situates his interpretation of these phenomena [21]. For when analyzing a specific universe, the researcher needs to observe and participate in the life of that place, as if he were a member of the group, in order to understand the dynamics of that space through the point of view of its agents. In addition, it is also necessary to maintain an outsider perspective, not absorbing personal interactions and results [22].

An attempt was made to understand the teaching/learning phenomena, according to the perspective of the participants. The researcher participated in activities of academic life as a teacher of the design studio discipline in the classroom, in order to understand the dynamics of this space through the point of view of its agents, during the learning process, obtaining data for comparison.

3.1 Describing the development

In the first stage of the research, the guidelines and the state of the art of architecture teaching were studied and the use of AutoCAD (Autodesk) and Sketchup (Trimble) software was analyzed.

In Brazil, the use of CAD technologies in the design area began in the 1990s in architecture and engineering schools, followed by their use in various stages of the construction process of buildings. The adoption of the AutoCAD platform was a natural process due to its wide use in the Architecture, Engineering and Construction (AEC) industry globally. The Federal University of Minas Gerais (UFMG) was a pioneer in Brazil in establishing, in 1997, a cooperation agreement with Autodesk to obtain free AutoCAD and other software. There was other computer aided design software but on a smaller scale of use. At the time, AutoCAD's advantage over other platforms was its portability to be used on personal computers (PCs), without requiring more robust and expensive hardware. In this way, AutoCAD became popular in Universities and among small and medium-sized companies, and architecture offices. Its use gradually grew in architecture and engineering schools in

Brazil, which significantly influenced its adoption by most professionals in the Architecture, Engineering and Construction (AEC) industry. In this context, several companies began to develop applications and customizations using the AutoCAD platform, facilitating and automating project development practices and processes, including standardization and customization for Brazilian standards focused on productivity.
For the three-dimensional digital modeling, the students used the Sketchup platform, which allows them to visualize the project. Its simplified interface facilitated 3D modeling and digital model creation. Visualizing a digital project similar to a real project makes it easier to understand, especially for those with poor spatial vision. The three-dimensional modeling process can help architects in making decisions for the development of the project and can help lay people understand the building.

Currently, learning and qualification in the use of project development platforms are essential in Architecture and Engineering schools. The fluency in the use of CAD tools associated with the BIM methodology qualifies people for the application of this new paradigm in the management of buildings throughout their life cycle. The professionals involved in the constructive process of the life cycle of a building can have an understanding of the whole from information on the geometric model. In addition to facilitating and streamlining the civil construction process, these geometric and information modeling tools allow taking individuals' creativity to other levels. The big challenge to be overcome was the barrier of thinking that functionalities and tools could reduce individual creative capacity. On the contrary, making the individual's creativity flow and elevate depends only on overcoming their difficulties to qualify in the use of the BIM methodology.
Another challenge to be overcome is the change in reasoning and procedures to transition from the design process of a two-dimensional model to a realistic three-dimensional model. This transition requires a change in the way of thinking about the project and the construction of the information and data model generated from the direct integration between design, simulation and reality.

The second stage of the research was developed based on the curricular matrix of a School of Architecture. The analysis considered how the matrix was applied, the pedagogical project and the method used to teach the classes. Each teacher was free to develop the dynamics between practical and theoretical classes and the transmission of knowledge.

The third stage of the research consists of observing the dynamics in the face-to-face classroom, monitoring and evaluating the transition and interaction between students and teachers in the use of new technologies. In the next step, the results of the learning process will be presented, evaluating the development of students' skills and comparing such results, in addition to consolidating the final results. For validation of the research, questionnaires and interviews with students and teachers who participated in the whole process are foreseen.

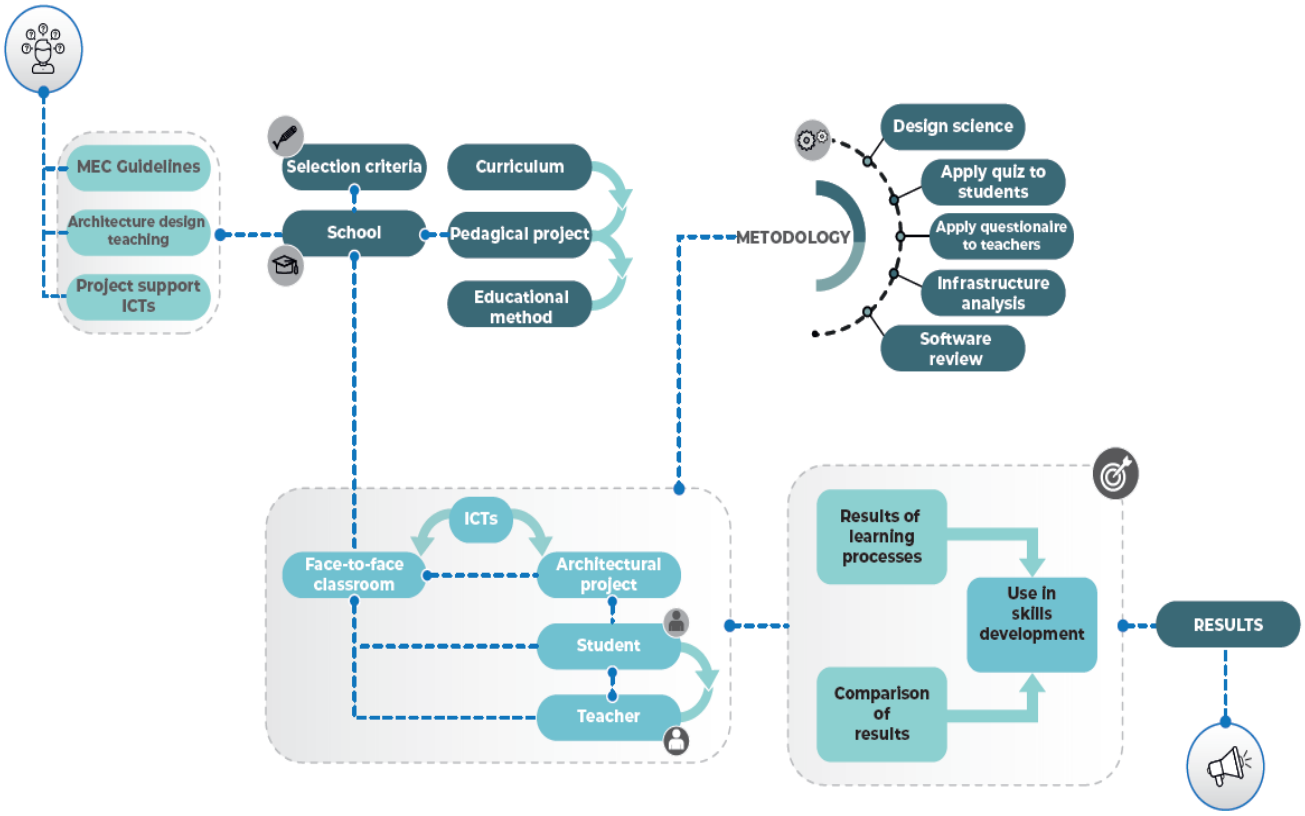

Figure 01 – Framework. Source: the author

4. TEACHING ARCHITECTURE

The teaching of architectural design in design workshops will be analyzed in a school of architecture at a private university and at a school of engineering at a federal university. The teaching of design architecture in traditional classrooms has been a relevant focus of discussions. Problems arising from traditional teaching models, which are still practiced in Brazilian architecture schools, are frequently discussed and analyzed, mainly in design studios. The author's experience as a teacher in an architecture design studio at an architecture school will be analyzed and discussed.
The experience of supervising and guiding students for 20 years has allowed us to observe important changes in the process of designing and producing projects in the classroom, due to the influence of Information and Communication Technologies.

These changes had a significant impact on the relationships between teachers and students. Nowadays, most students start the architecture course with prior knowledge of CAD design software and know some concepts of the BIM methodology to model the life cycle information of a building. Some teachers still lack the skills to use such tools, which hinders and delays the implementation and use of these new technologies. This factor can be interpreted as a clash of generations between masters who hold knowledge and students who are eager and qualified to learn technology. The first with the natural difficulties to assimilate the changes in the speed with which they appear and the second with the inherent facilities of their generation. The difficulty of accompanying this transition is the result of the speed with which technologies happen these days, which has been a problem even for young people.

The need to incorporate digital tools into the studio's design process triggered a split between teachers resistant to change and those adept at new technologies. The students involved in a design studio have 3 teachers available simultaneously. Before the appearance of digital tools, the processes of design disciplines in studios consisted of manual drawings and sketches. Several architects understand this activity as a process inherent to the production of the project and that digital tools help in the finalization phase of the project [20]. This discussion is related to the question of defining the project phase, in which the technology should start to be used. Opinions differ on two fronts. The first, more conservative, defends the preparation of the project manually and then the use of technology to represent and finalize the project. The second would use technology from the beginning of the design, creation and finalization processes of the project.

Considerable changes are already being foreseen. Some professors and students already skillfully use important tools in the process of designing, creating and developing projects.

In this way, problems arose and became recurrent within the design studio. We can quote unmotivated students, Professors discredited in the ability of students; low quality of work deliveries; unmotivated manual draft; the student's ability was not taken into account, but the teacher's ability to expose the problem and the tools required to solve it; the final evaluation was centered on the teacher's opinion, which was considered to hold the knowledge; Professor' doubts about the way of teaching.

With the delivery of the students' tasks, some teachers began to perceive and to verify that the technologies that were already part of the daily life of these students should be incorporated as tools to aid in teaching. Even with these observations, some professors still insisted on the opinion that technological tools should be used as project finalization tools.

5. FINAL CONSIDERATIONS

We live in times of very rapid changes influenced by advances in technology in a process of major transformations, creating new relationships between environments and the way of life. Scholars have shown that the effects of these changes reached schools, which has aroused academic interest in the subject. The discussion about the role of the environment and technology in the performance of teaching and learning functions has been the subject of reflection and studies.

It is of great importance to understand how architecture schools are facing the inclusion of new technologies and how they can benefit from the support of digital tools in teaching. The architecture school plays a key role in keeping up to date with this new pace of availability and access to information. To this end, it is necessary to encourage reflections on new topics and rethink the entire physical space to favor and enable a good student-teacher relationship. The teaching environment currently used must follow the new trend, to allow the student to work and share their experiences with each other and with their teachers, experimenting, stimulating, creating and building their knowledge.

The Professor must encourage and create conditions for the insertion of technology as an aid tool throughout the design process. Classrooms must be adequate to allow the inclusion of this new reality. It is believed that this technological influence will enable the redesign of the new classroom. Authors claim that technologies began to be used to transform schools themselves, making curriculum organization and teaching/learning management more flexible.

Learning spaces need to be adapted to the new ways of designing and be prepared for the use of technologies in harmony with the traditional way of producing design.

Another factor of great importance is the training and qualification of Professors, so that they can face the new generation of students, who grew up exposed to digital accessibility. The situation presented demonstrates that the way of teaching design in a face-to-face workshop is changing as Information and Communication Technologies (ICTs) are increasingly closer to our activities.

This everyday reality was considered in this study to assess the adaptation of the school, teachers and students to new technologies and new ways of teaching and learning.

The study analyzes the relationship and conflicts between Generation X of Professors and Generation Z of students, born in a digital environment, and demonstrates the difficulty of interaction between these generations. In this context,

developing the ability to design and teach design is a challenge for Professors of Generation X, which requires a great effort to update and qualify in new technologies.

We are in another possible paradigm break, beyond the imaginable, where the evolution of Artificial Intelligence can be applied for the creation of contents (projects), or even to replace professionals in tasks from simpler or complex tasks.

6. ACKNOWLEDGEMENTS

"This work was carried out with the support of Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Financing Code 001". The Transcolar Rural Project of the Engineering School, Federal University of Minas Gerais - Brazil (EEUFMG).

7. REFERENCES

[1] R. M. A. Baracho, P. A. Diesel. Information Management Processes for Extraction of Student Dropout Indicators in Courses in Distance Mode. **Journal of Systemics, Cybernetics and Informatics**, v. 14, p. 1-6, 2016.

[2] M. L. Pereira Junior, R. M. A. Baracho . **Relações entre a gestão da informação e do conhecimento e uso de sistema BIM por arquitetos e engenheiros**. In: 4o. Seminário Ibero-Americano Arquitetura e Documentação, 2015, Belo Horizonte. Anais do 4o. Seminário Ibero-Americano Arquitetura e Documentação. Belo Horizonte: Mestrado em Ambiente Construído e Patrimônio Sustentável MACPS e IEDS, 2015. v. 1. p. 1-12.

[3] C. Eastman et al. **BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors**. New Jersey: John Wiley & Sons, Inc., 2008. 490p.

[4] B. C. Björk, M. Laakso, CAD standardization in the construction industry – A process view. **Automation in Construction**. v.19, n.4, 398-406 pp, 2010.

[5] M.F. Porto, J.R.Q. Franco, R.M.A. BARACHO, **Paradigma de Utilização da Tecnologia BIM para Projeto Arquitetônico e de Engenharia**. 4ª Seminário Iberoamericano Arquitetura e Documentação. Belo Horizonte, MG, Brasil. 2015.

[6] C.A. Jacoski, **O Intercâmbio de Dados entre SIG e Projetos de Edificações – A Busca pela Interoperabilidade**, Universidade Comunitária Regional de Chapecó. 2008.

[7] U. Flemming, H. Erhan, I. Özkaya, Object-oriented application development in CAD: a graduate course. **Automation in Construction.** v.13, 147-158 pp, 2004.

[8] U. Isikdag, J. Underwood, Two design patterns for facilitating Building Information Model-based synchronous collaboration, **Automation in construction,** 2009.

[9] L. Bacich, A.T. Neto; , F. M. Trevisani. **Ensino híbrido: Personalização e tecnologia na educação**. Porto Alegre, RS: Penso, 2015.

[10] M. L. Natalino, T. Tiburcio. **O uso de tecnologias digitais para qualificar o ambiente de aprendizagem de uma proinfância**. Design & tecnologia. Universidade Federal do Rio Grande do Sul, 2018.

[11] L. S. Vygotsky. **A formação social da mente: O desenvolvimento dos processos psicológicos superiores** (J. C. Neto, L. S. M. Barreto, & S. C. Afeche, Trads.). São Paulo, SP: Martins Fontes, 1989.

[12] L. M. C. Bezerra, M. L. L. S. Choas. **Características do espaço arquitetônico facilitadoras do ensino e aprendizagem**. Florianópolis, Intertheses, v.13, nº 02, p. 58-75, 2106.

[13] J. M. Moran. 5ª ed. Campinas , SP: Papirus, **A educação que desejamos: Novos desafios e como chegar lá.** 2012.

[14] T. Tiburcio, **The impact of high-tech learning environments on pupils' interactions**. PhD. Thesis. The University of Reading, Reading. UK. 2007.

[15] R. Carvalho, A. Savignon. **O professor de projeto de arquitetura na era digital: desafios e perspectivas. Gestão e Tecnologia de Projetos**. v. 6, n. 2, 2012.

[16] R.M.A. Baracho, B. C. Soares, R. A. Bonatti, M. F. Porto, J. R. Q. Franco. Decision Making in Real Estate Developments Based on Building Information Modeling. **Journal of Systemics, Cybernetics and informatics**, v. 17, p. 49-54, 2019.

[17] S. I. Andrade, P. Mendes, D. A. Correa, M. F. Zaine, & A. T. Oliveira, (2012). **Conflito de gerações no ambiente de trabalho: um estudo em empresa pública.** Anais do 9º Simpósio de Excelência em Gestão e Tecnologia. Resende, RJ, Brasil.

[18] A. L. Maurer (2013). **As gerações Y e Z e suas âncoras de carreira: contribuições para a gestão estratégica de operações**. (Dissertação de Mestrado Profissional em Administração, Universidade de Santa Cruz).

[19] V. M. Kensky. **Educação e tecnologias: O novo ritmo da informação**. 8ª ed. Campinas, SP: Papirus, 2012.

[20] T. Tiburcio, Z. Braz. Mídias e espaço as sala de aula no ensino de projeto arquitetônico. **Artefactum: Revista de estudo em linguagem e tecnologia**. N.2, 2016.

[21] NEVES, José Luis. **Pesquisa Qualitativa – Características, usos e possibilidades. Caderno de Pesquisa em Administração**, São Paulo, v.1, n.3, 1996. Available at: http://www.ead.fea.usp.br/Cad-pesq/arquivos/C03-art06.pdf Acesso em 20 set.2020

[22] GROAT, Linda; WANG, David. **Architectural Research Methods**. N. York: John Wiley & Sons, 2002.