Future architecture: Use of Artificial Intelligence in sustainable construction projects

André Cunha Leitão
Carl Erhard Dolder Amaral
Pedro Laudisio Henriques
Advisor: André Lozano Ferreira

ABSTRACT

The population increase is related to the increase in the production of waste that is harmful to the environment. Even in 2024, in Brazil, most civil construction projects are not carried out with sustainability, generating several environmental impacts. The consequences will manifest themselves in the long term, which reduces the urgency of the issue. The focus of architecture is to design environments to improve people's quality of life. Thus, the objective of the study is to help society minimize environmental damage in civil construction, with the development of an App based on Artificial Intelligence, as a support for the digital and sustainable transformation of Brazilian architecture. The methodological approach is qualitative, based on interviews and, in a complementary way, the development of a prototype was carried out. To collect data, interviews were conducted. A semi-structured script supported the interviews, with the due approval of the school's ethics committee. From the analyses, it was possible to develop a prototype. The participants in the interviews made important contributions to future studies. The study points to the fact that artificial intelligence should be an ally of society in the development of sustainable solutions, such as architecture and civil engineering. The development of an App allowed the experience of using an innovative and digital solution with sustainability, as well as the confirmation that the main contribution of the study is to help society with actions to minimize damage to the environment.

Keywords: Future Architecture, Sustainable Materials, Artificial Intelligence, App

1 INTRODUCTION

The population increase is directly linked to the production of waste harmful to the environment (Ecoresponse, 2021) since, with the population increase, the demand for housing and infrastructure is aggravated and, in 2024, construction projects are not carried out sustainably and generate environmental impact (Moraes & Souza, 2015). There is a disregard by the population regarding environmental issues and a certain stigma related to it, as the consequences of neglecting the environment are not immediate and will take a long time to appear (Sousa, 2024). The main focus of architecture is to design environments to improve people's quality of life (Revistasim, 2024). Architecture has always been present in human society (Rocaceramica, 2022) and has been following technological evolutions over time (Casttini, 2023).

The development of innovative technologies is essential for the advancement of various fields, such as medicine (Reis, 2019), engineering (Sólida Engenharia, 2022), and architecture (FNA, 2024), improving quality of life and promoting sustainability. The exponential growth of Artificial Intelligence (AI) constantly challenges the limits of technology and how to use it for the benefit of the environment and the population (ICMC Junior, 2021). Its various applications allow for the revolution of several market areas, such as medicine, engineering, programming, and architecture, aiming to improve the quality of life of the population. In this context, the following question arose: What is the importance of making architecture more sustainable supported by the use of innovative technologies?

The initial proposal to be deepened in the study was the development of an app that uses AI to assist in construction projects through image generation following user requirements, always prioritizing materials and strategies that do not degrade the environment. There are not many technology options that perform this function, whether free or paid, therefore, this study used the development of an app, based on MIT App Inventor, as a prototype, to prove the findings and assist in learning about the studied topic.

It is believed that integrating AI into construction projects will be extremely beneficial for society towards the development of sustainable architecture. The study had an exploratory nature, and the main objective was to analyze the importance of making architecture more sustainable supported by the use of innovative technologies, such as Artificial Intelligence, as a proposal to solve one of Brazil's biggest problems, the lack of use of sustainable tools in architecture and building constructions, increasingly harming the environment (Mundo Isopor, 2024). Furthermore, it is important to deepen knowledge about Artificial Intelligence (AI), Machine Learning, and their use in the fields of architecture and engineering. The high emission of polluting gases, such as CO2, caused by means of transport during the essential stage of a construction project and throughout the life cycle of the materials used, has been bringing numerous problems to planet Earth. This sector is responsible for the emission of 30% of polluting gases in the atmosphere, as well as the use of 50 to 75% of the world's natural resources and the deforestation of green areas, triggering many more problems (Folha Vitoria, 2024). Using Artificial Intelligence, it is possible to develop an application for mobile phones and computers, focusing on solving this problem. In the application, the user can create architecture projects from images and ideas, where AI indicates the best materials and the best ways to implement the project sustainably, considerably reducing the damage caused to the environment.

The study addressed architecture with a focus on sustainability, which provides benefits both for people and the environment, to expand the issue of having sustainable materials for a better world, through artificial intelligence, in relation to various polluting materials that are manufactured and introduced in civil constructions that affect the environment due to their manufacturing, which can affect air quality, soil damage, and water, among other factors. One of the changes that this work can provide is to reduce the pollution rate in the world and provide an experience with sustainable materials in their homes, etc. Among the possible experiences identified, there is the connection with sustainable materials that can bring a more naturalistic landscape and the possibility of reconnecting nature to humans, all through artificial intelligence. One of the ways to leverage this work would be topic 11, Sustainable Cities and Communities, which meets the Sustainable Development Goals (SDGs), which are a set of global goals established by the United Nations General Assembly. This topic 11 addresses the increase in sustainable materials to reduce pollution and not only that but also improve domestic comfort in both urban and rural areas through these sustainable materials. With the application of this goal, there is less pollution, inequalities, among other factors (SDGs, 2024).

2 THEORETICAL REVIEWS

2.1 Sustainable Construction Projects

Sustainable construction projects are extremely important for the environment since construction projects tend to generate large amounts of waste harmful to the environment (Moraes & Souza, 2015). Therefore, it is necessary to have construction projects carried out sustainably to minimize the impacts generated on the environment by this industry, which today comprises 34% of the Brazilian industry and is responsible for 6.8% of Brazil's GDP (ACMA, 2024). They are directly linked to the SDGs as they aim to reduce the amount of damage generated to the environment in a sector that ends up harming it. Sustainable construction projects are connected to the following SDGs: 9 (industry, innovation, and infrastructure), 11 (sustainable cities and communities), and 13 (climate action).

2.2 Use of Artificial Intelligence in Architecture

Human curiosity has always sought to understand and replicate its own reasoning capacity (Silva & Mairink, 2019). With this goal, the term Artificial Intelligence (AI) was coined by Alan Turing in 1950 in his work "Computers and Intelligence" (Kaul et al., 2020). AI aims to emulate human thought through computers that, using learning techniques, process vast sets of data, known as Big Data, allowing machines to reason analogously to humans (Silva & Mairink, 2019). Big Data is crucial in machine learning, defined by Chivegatto Filho (2015) as extensive data that transforms traditional analysis. These are complex collections that require advanced methods for their analysis and categorization. For this, machine learning techniques are employed to detect intricate patterns in these data (Ngiam & Khor, 2019). Machine learning comprises algorithms that enable machines to solve

problems through pattern identification (Ngiam & Khor, 2019). These algorithms result from the intersection between mathematics and computer science, analyzing large volumes of data to create statistical models. They are divided into two categories: Supervised Learning and Unsupervised Learning (Deo, 2015). Unsupervised Learning works with unlabeled data to classify them and allow the machine to learn autonomously. On the other hand, Supervised Learning uses pre-classified data to train the machine to solve similar problems. According to Deo (2015), Supervised Learning specializes in subdividing these data for a more precise description. Among these techniques, the Decision Tree stands out, which is a statistical model that interprets data to show different possibilities for each branch (Chivegatto Filho, 2015).

2.3 Use of AI in Sustainable Constructions

AI holds the key to unlocking new frontiers in sustainable architecture. Its potential lies in its ability to analyze extensive data, create efficient designs, predict future trends, and optimize building operations. Essentially, AI transforms static buildings into dynamic entities that learn and adapt. A perfect example of this is "The Edge" in Amsterdam, a masterpiece of sustainable architecture. It's not just the abundance of solar panels or the underground thermal energy storage that make it stand out. It's the intelligent software that learns the behavior of the building's occupants and adjusts the environment to optimize energy use (Ugreen, 2024). Engineered wood has emerged as a sustainable alternative to replace concrete components in construction, as concrete alone contributes to 8% of global CO2 emissions. With various examples across different scales and programs, this material has shown promise in revolutionizing the industry, adding efficiency, strength, and comfort. Even when dealing with highly standardized and efficient processes in the manufacturing of structural pieces, there is always room for improvement and waste reduction. Mainly because the traditional industrial process of sawing logs into parts can generate substantial waste. It is in this context that A.I. Timber emerges, an innovative construction material designed to minimize waste by preserving the natural contours of trees. Instead of conventional methods of sawing single logs into standardized boards, A.I. Timber ingeniously uses Artificial Intelligence to fit these logs together like perfectly assembled puzzle pieces. (Souza, 2023).

3 METHODOLOGICAL PROCEDURES

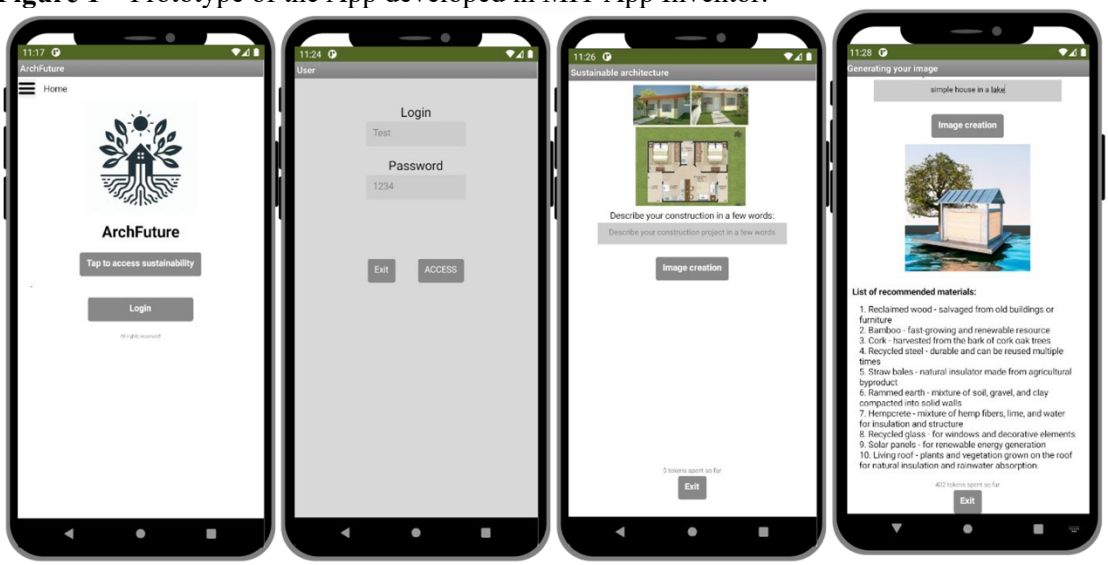
The research in question focused on a qualitative study, aiming for a deeper and more detailed understanding of how architecture can evolve sustainably and how artificial intelligence can contribute to minimizing environmental impacts in the field of engineering and architecture. The central object of the analysis was sustainable development, which was also the main interest in investigating the phenomenon under study. The study plan included conducting interviews with five professionals in the architecture sector in Brazil, whether they are students or professionals already graduated in architecture and engineering. The data collection method was structured by a specific interview protocol. According to Creswell and Creswell (2021), researchers should plan how data will be collected before starting fieldwork. Thus, the interviews were conducted in person, respecting the availability and preference of the interviewees, maintaining individuality and confidentiality. With the participants' permission, the interviews were recorded for transcription and analysis. Following Creswell and Creswell's (2021) guidelines, a limited set of questions was prepared to provoke reflections and opinions from the interviewees. Notes were taken during the interviews for documentation and to avoid repetitions. The interview protocol also includes, according to Creswell and Creswell (2021), the recording of basic interview information, procedures for introduction, creation of an initial question, development of content questions and conclusion of the interview, use of probes, and closing of the interview. The interview helped map all the problems and challenges related to the research topic, as well as suggest and validate potential solutions.

4 FINDINGS

Initially, a challenge was presented: Identify a social problem and propose a solution, with the possibility of being implemented, focusing on doing and digitally, according to Blikstein and Krannich

(2013), using systems and technology that enable its programming, allowing the development of computational skills, following the guidelines of Papert and Harel's constructionism (1991). To this end, a brainstorming session was held among the group members to decide among various themes raised by the group, which would be the study theme. The Sustainable Development Goals (SDGs) were used as a guide for the solution to be developed. The goal "Make cities and human settlements inclusive, safe, resilient, and sustainable," item number 11, more precisely item 11.6, which says "By 2030, reduce the per capita environmental impact of cities, including by paying special attention to air quality, municipal waste management, and others." From this goal, we were able to identify a problem in our society, the pollution caused by the stages in building constructions. Given the problem of reducing the emission of polluting gases during construction stages, the creation of ArchFuture becomes an interesting contribution to society, including contributing to the theme of universal health coverage, preventing people with respiratory problems from being further harmed by air quality, reducing the amount of polluting and harmful gases to human health in the atmosphere. The solution is presenting login options on the platform, introduction of the image of the place to be built, and description of the structure according to the user's preference, which, with the use of artificial intelligence, will suggest an architectural project with a list of sustainable materials that fit the requested description, as shown in Figure 1.

Figure 1 – Prototype of the App developed in MIT App Inventor.



Source: Authors (2024).

All participants collaborated with the prototype format and the necessary improvements to the functionalities. Based on suggestions and feedback, it is possible to understand that the development of the app will be extremely useful in Brazilian society. All interviews were duly recorded with the participant's permission, transcribed, and allocated in an external video and audio document.

5 CONCLUSIONS

The study achieved its objective by analyzing the importance of making architecture more sustainable, supported using innovative technologies such as AI. The initial proposal deepened in the study was the development of an app that uses AI to assist in construction projects through image generation, following user requests, always prioritizing materials and strategies that do not degrade the environment.

MIT App Inventor was used as the ideal solution for the development of the app, allowing the use of AI in its block programming. The app, even in its initial version, proved to be promising and interesting for some experts in the field of architecture and participants.

Thus, it is recommended to conduct a larger number of interviews, seeking insights, possibilities, and low-cost alternatives in future studies. Technology allows the development of various

functionalities, but identifying the best options for sustainability is a challenging yet very promising activity. Architecture can evolve sustainably, and AI can contribute to minimizing environmental impacts in the field of engineering and architecture, preparing society to seek inclusive, sustainable, and truly valuable alternatives.

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