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Architectural design of classroom to stimulate learning in Higher Education: An Approach Connected with Neuroeducation and Neuroarchitecture

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Abstract

The architectural design of learning spaces in higher education has undergone profound changes with the new educational perspectives that break with traditional pedagogical practice supported by control, hierarchy, and information dissemination. Educational institutions are gradually seeking disruptive models that enhance new learning experiences. This article presents references of innovative projects of learning and interaction spaces, that have been added to the principles of Neuroeducation and Neuroarchitecture for the development of architectural strategies for a new classroom proposal for the Bahia State University. As a result, the project brings preliminary studies to the Learning Environment Model for Higher Education (LEMHE). A flexible model, divided into three learning areas: flexible zone (active); introspection zone, and relaxing zone. This zoning aims to provide diverse experiences of pedagogical practices, added to respect the physiological needs of its users to enhance well-being and learning in higher education.

Keywords: Classroom; learning; neuroarchitecture; neuroeducation; higher education

1. Introduction

The evolutionary scenario of classroom architecture shows that since the early civilizations these environments have been structured to support the dissemination of information based on the social and cultural values of their time. This occurred in the first Eastern and Western civilizations and throughout history, where architectures supported the dissemination of information, either exalting religious principles, or seeking to meet the principles of professional and intellectual training with the emergence of commercial relations.

These principles guided educational practices aimed at higher education, configuring the evolutionary architecture of classroom models: Individual teaching model used in corporations of trade; collective teaching present in medieval universities; and simultaneous education, inherited from basic education by colleges and higher schools. Architectural classroom model for simultaneous teaching designed for a 19th-century reality.

From the 19th century to the 21st century, the world has undergone many changes: social, cultural, and technological, and these changes present new perspectives of reading the educational practice and the architectural concept. This new look at contemporary reality validates the human experience and is already being reflected, albeit on a small scale, in some innovative projects aimed at education, in the world and in Brazil.

However, despite the renewed look toward educational practice anchored in contemporary educational principles, which already see in student-centered teaching (SARMENTO; GOMES, 2019) and in the development of social and emotional skills (CAMARGO; DAROS, 2018) the most efficient path to learning; and the emergence of architectural references, which demonstrate the feasibility of materializing these principles, it is still common to reproduce the architectural model of the classroom for simultaneous teaching designed for the reality of the nineteenth century, which stimulates a traditional pedagogical practice supported by control, hierarchy, and information dissemination.

Reality that is decontextualized in the face of new dynamics: that transformed the way people communicate, access information, relate, work and study, and that is present at the State University of Bahia (UNEB).

In an attempt to connect UNEB to the current context and enhance learning experiences, this article is the result of an ongoing master's research in the graduate program in Management and Technologies Applied to Education (GESTEC), which has as theme the architectural design of the classroom, delimited in the contemporary principles. It discusses the elements of how to design a new university learning environment that evolves with the traditional environment and that contribute to learning through positive experiences in the relationships between users and between users and the built environment. In this way, this article aims to present a preliminary study of the Learning Environment Model for Higher Education (LEMHE), a teaching environment-university learning that dialogues with the contemporary context to enhance the learning and well-being of users. This project is based on modern interaction spaces presented in "materials and methods" and theoretical principles of Neuroeducation and Neuroarchitecture. To carry out the architectural project, the methodology Design Science Research (DSR) was applied because it is anchored

in the science of design, which integrates research and design for the conception of a new product to be used in a social context. In the present case, a conceptual model of learning environment aimed at higher education.

2. Material and methods

History shows us that educational institutions, to overcome decadence, have evolved in line with the technological, social, and cultural demands of their time. Thus, in an attempt to collaborate for potentializing the learning at UNEB, stimulating the connection with contemporary educational demands, it was sought to understand how some architectures of learning environments are adapting to new educational demands.

For this purpose, it was selected three architectural projects that materialize the new perspective for 21st century education, and they will be used as reference material to obtain architectural strategies. Thus, collaborating in the rereading of the university learning environment to UNEB, to be proposed in this research.

Since the 20th century these differentiated learning environments are easily found for early childhood education, gradually gaining space in high school, and lately also coveted for higher education. Although still composing a small spectrum in the face of the reality of educational architectures, these innovative environments become reference for reality transforming movements.

In the search for new references of innovative projects, which would provide new architectural strategies that reflect perspectives of new theories, the following projects were selected: Future Classroom Lab (FCL), from Setubal, Portugal; the middle school Orestad Gymnasium, established in Copenhagen, Denmark; the higher education school École 42, headquartered primarily in Paris, France; and the Albert Einstein Hospital Education and Research Center, São Paulo, Brazil.

2.1 Future Classroom Lab (FCL)

The Future Classroom Lab (FCL) or Future Classroom Laboratory, first set up in the city of Brussels, Belgium, and later in the city of Setúbal, in Portugal, was born as a research project developed by the non-profit organization European Schoolnet, whose mission is to support the European Ministries of Education in decision-making regarding professional development in education, dissemination and technological innovation in teaching and learning, as well as connecting researchers and industry partners with educational institutions in Europe, aimed at enabling educational transformations that can meet the demands of digitized 21st century European societies (EUROPEAN SCHOOLNET, 2019).

The Classroom Lab of the Future was conceived as a tool to apply the results of a prior project developed between 2010 and 2014, Innovative Technologies for an Engaging Classroom (iTEC), which brought important results and recommendations for the implementation and development of innovative teaching and learning scenarios with the use of Information and Communication Technologies (ICT) (ERTE, 2019) by making European classroom spaces a learning environment that challenges students and teachers to rethink the role of pedagogy and technology in classrooms.

Intending to consider the recommendations on the use of ICT in learning processes, the European Schoolnet

proposes the reorganisation of the traditional classroom space, structuring a new space organization that supports innovations in the teaching and learning methods proposed by iTEC, thus emerging the proposal of the Future Classroom Lab, a laboratory with six different learning spaces: Create, interact, present, investigate, share, and develop (Figure 1). Each space highlights specific areas of learning and teaching and helps rethink different points: physical space, resources, changing roles of students and teachers, and how to support different learning styles (FCL, 2019) (Figure 2).

Faced with pedagogical innovations, which strengthen the various forms of learning, that are translated into a space organized in a modular way, the project developed by European Schoolnet was included in this research as a project reference that subsidized the first approximation of research with the development of the architectural project of MandacaruLab -UNEB, which will be described later.

Figure 1. 3D model representation of the Future Classroom
Source: EUROPEAN SCHOOLNET, 2019

Figure 2. Future Classroom. Secondary School D. Manuel Martins, Setúbal, Portugal.
Source: DN, 2018.

This architectural project of learning environment absorbs the theoretical principle of different learning, which dialogues with the theories of David Thornburg who defends a spatial organization that allows the student to experience different types of learning (with specialist, with peers, by introspection, doing) (SARMENTO; GOMES, 2019, pg.114).

Theories that connect with the neuroscientific advances of the 90s, such as the Gardner's theories of multiple intelligences (1983) (TOKUHAMA-ESPINOSA, 2008, pg. 42), which begin to understand the functioning of the brain making it possible to identify the best educational practices. However, a proposal that demonstrates, in the understanding of this research, rigidity and little flexibility.

2.2 Orestad Gymnasium

The Orestad Gyminasium is a public high school founded in 2005, which offers the study of language, history, and mathematics through lines of research such as: Natural sciences; humanities; social sciences and arts, with digital media and technologies as learning tools.

It was selected as a reference for this research because it is a pedagogical project that values group work and simulates a practice equivalent to what occurs on a university campus, such as UNEB, which offers several fields of study. However, this project differs by allowing all the different fields to print their views on the same subject, developing a significant, shared, and collaborative learning process.

The architectural design of the school was developed by the Danish 3XN office, which offers a low floor

plan that is organized around a central staircase. This proposal dialogues perfectly with the pedagogical ideology that understands that the school of the future must be the one that is able to accompany the pedagogical changes. For this, the architectural project proposes the rupture of the walls that close the classrooms, allowing the expansion of learning to open environments, known as Open Learning Spaces (figure 3). In this way the architecture of the Orestad Gymnasium school has as main characteristic its open spaces for learning. Spaces designed to be flexible and transform according to the needs of their users (ARCHIDAILY, 2019).

An educational architecture designed to catalyze new ways of thinking about teaching, whether in environments organized in a more traditional (figure 4) or more flexible way, where the visibility of the environment, whether with the use of glass or demolishing the walls, is used as an architectural strategy to: Enhance the use of active pedagogical practice; stimulate the rapprochement between students and teachers; and raise awareness to use the environment in order to collaborate with the concentration of the other. Architectural strategy and methodologies, which according to educational innovation specialist Anne Penido (FUTURA, 2016), are necessary in contemporary education to establish more affective, trust and exchange relations, thus keeping students and teachers motivated and participatory in all processes offered.

Figure 3. Open learning spaces
Source: FUTURA, 2016.

Figure 4. Classroom with glass wall
Source: FUTURA, 2016.

From this architectural project it is extracted the theoretical perspective of open learning environments: either extinguishing the walls or replacing them with transparent glass. This perspective is also in line with the understanding about the functioning of the brain, which requires about 20 to 25% of the available energy for its normal functioning (SUSSMAN, 2021). This need increases when survival zones are activated, occurring, for example, when the sense of orientation is compromised by blocking the visibility of what happens around users, thus decreasing the energy required for other brain zones, as in learning.

The contemporary theory that focuses on learning from the understanding of brain functioning is called Neuroeducation, as conceptualized by author Tokuhama-Espinosa (2008). Theory that, in the understanding of this research, evolves the theory of the active methodologies of the twentieth century, which reach the twenty-first century supported by the scientific proof of its potentialities in maximizing learning.

2.3 École 42

The École 42 is a private school of higher education aimed at the training of computer programming, offered free of charge. Its first headquarters, an architectural project of the English office Edit Architecture,

was inaugurated in Paris in 2013, conceived and financed by the French entrepreneur of the telecommunications branch, Xavier Niel (1967) together with the executive Nicolas Sadirac (1968) former director of the network of Epitech school. Today with branch in more than 10 countries, including two headquarters in Brazil (Rio de Janeiro and São Paulo).

Educational concept that breaks with the theoretical education of the classroom, with fixed schedules and days, and the need for the presence of a teacher. It is focused on point-to-point learning (networking), which distributes tasks among peers; project-based learning; and gamification, stimulating collaborative work to empower young people to work professionally as software engineers (42FR, 2013).

For this, its architecture is developed to work twenty-four hours a day, seven days a week. An open campus, designed to be accessible and inclusive, offering all the physical and technological structure necessary for student training.

The facilities have environments such as: The "clusters", computer rooms designed to facilitate exchange, group work and concentration (Figure 5); the "The Bocal", the core of the members of the school's training team, where the challenges are passed and doubts are cleared; and the decompression spaces such as the arena, which offers video games and virtual reality (VR), the canteen, which offers vending machines for food and drinks in addition to the Food Truck with fresh foods and game tables; and modular environments, with furnishings that provide flexibility in space organization (Figure 6).

Figure 5. Cluster, École 42, Paris
Source: 42FR, 2013.

Figure 6. Modulated environment, École 42, Lisbon
Source: 42LISBOA, 2020

From this architectural project it is obtained the theoretical perspective of spatial flexibility, reflected in the concept of modular organization of the environment, which is understood to also be based on the theoretical principle of the different learnings of David Thornburg, described by Sarmento and Gomes (2019), and the potential protagonist of users in the organization of spaces according to individual needs, as well as in the proposal developed by pedagogy Reggio Emilia. This proposal breaks with the rigidity identified in the presented Future Classroom Lab project.

More flexible environments, stimulating more engaging activities, which collaborate with greater motivation among users, is imbricated with the theory advocated by Christensen, Horn and Johnson, where motivation is the main element in teaching-learning processes because it generates engagement, driving students to take a leading role in the construction of their learning (CAMARGO; DAROS, 2018, pg. 06).

2.4 Hospital Albert Einstein education and research center

The Safdie Architects office project, based in Boston, features an architecture focused on higher education

that focuses attention on a central green atrium, where the environments are organized around it.
It is in a hilly terrain that values the implantation of an amphitheatre in this central atrium, which connects two different wings of the building: One dedicated to teaching facilities and the other dedicated to research. Designed, according to e-Pavilion (2018), to become an urban oasis, the incorporation of nature in the internal environments is a striking perspective in this work. Educational environments also value both internal and external visibility with the abundant use of glass and are connected to small open and green courtyards, which can be used flexibly for various activities (Figures 7 and 8).

Figure 7. Open courtyards, gardens, and central atrium
Source: SAFDIEARCHITECTS, 2021

Figure 8. Open amphitheatre
Source: SAFDIEARCHITECTS, 2021

The architectural project of the Albert Einstein Education and Research Center, was selected to close this chapter of references because it seems to meet all the theoretical perspectives presented in the previous projects, besides proposing a new perspective: the incorporation of nature into educational environments. This new perspective is possibly anchored in the contemporary theory called Neuroarchitecture, which incorporates the concept of Biophilia (love of life) to its theoretical principles, because it understands the importance of the evolutionary connection between man and nature, which collaborates in the regulation of emotional levels, collaborating with the perception of well-being of the occupants of the built environments (KELLERT; CALABRESE, 2015).
Seeking to absorb the knowledge acquired from the theory and references of the projects presented, this research proposes to initiate approximations of possible solutions to the research problem, applying the knowledge to the professional practice at UNEB. For this purpose, the DSR methodology was used, focusing on the stages of observation and development, thus enabling the first approximation that occurred with the development of the MandacaruLab Laboratory project, requested by the University's Innovation Agency, and later a new approach to the project for the classrooms of the Department of Exact and Earth Sciences (DEES), both in 2019. Requests that demand projects that are born ideologically along side with the proposal of this research.

3. Results

3.1 MandacaruLab

Supported by the theoretical deepening of the Future Classroom Laboratory, associated with the new perspectives of spatial organization of work environments based on coworking and makerspace laboratories,

the architectural design of the MandacaruLab was elaborated (Figure 9): An innovative learning environment proposal for UNEB developed with the ideology of promoting connections between students and teachers: undergraduate; graduate; research groups and virtual communities, for the research development in the context of the creative economy, digital manufacturing, education, and innovation.

An innovative learning environment proposal, which had as a project guideline to provide environments that allow diverse learning, with a comfortable, creative, flexible, and technological structure. The observation of these guidelines directed to the development of architectural strategies such as: specification of furniture that adapt to various layouts and meet standards of comfort and ergonomics; selection of vivid colors in the furniture and in wall plots; reuse of traditional objects in a creative way, such as shelves made from stairs and sofas built with pallets; and provide access to technologies expanding the availability of the power grid and the Internet, as well as offering equipment such as the 3D printer, for the development of projects.

Such strategies conditioned the spatial configuration presented, representing an approximation of the redesign of the UNEB learning environment based on contemporary demands (Figures 10 and 11).

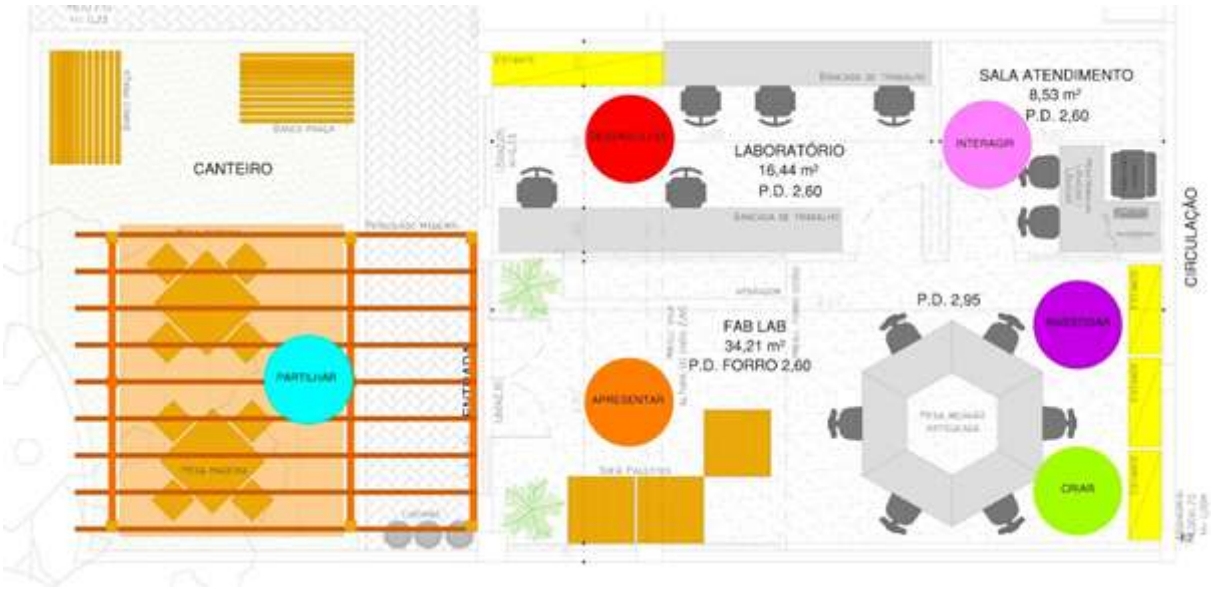

Figure 9. Low plant, learning zones MandacaruLab, UNEB.

Figure 10. Top View, 3D Architectural Layout Design MandacaruLab

Figure 11. Internal view, 3D Architectural Layout Design MandacaruLab, UNEB.

Unfortunately, the proposed project was not executed. The maturation resulting from the development of the MandacaruLab project and its inexecution led this research to the search for new contemporary theoretical bases that could help to evolve the learning environment model for UNEB. Theoretical evolution

applied in the development of the architectural project to reform two classrooms located in the Department of Exact and Earth Sciences (DEES), Campus 1, UNEB.

3.2 DEES classrooms

The existing classrooms at UNEB are standardized and structured to support traditional pedagogical experiences, offering individual and tiered desks for students, a whiteboard of notes, a projector, and an individual table for the teacher. It may or may not provide a computer, thus completing the instruments offered in the learning environment for the pedagogical practice (Figure 12).

A classroom designed for traditional teaching aimed primarily at individual and passive learning. With a rigid organization, it meets the maximum occupancy standard set at 1.15 m²/student by the Ministry of Education and Culture (FUNDESCOLA, 2002).

The request in 2019 for a renovation project of the classrooms came from the coordination of the department that, when presented to new possibilities of learning environments, showed interest in investing in a differentiated environment for the DEES.

Given this opportunity and in the expectation of seeing the project executed, an architectural proposal was developed, not a new learning environment as occurred with the MandacaruLab project, but rather a project that stimulated the transformation of classroom use from structural support to diversify active pedagogical practices, which would enhance the students protagonism. It was intended to gradually transform the traditional classroom environment, without completely breaking with the more traditional pedagogical practices.

For this purpose, the project proposed to include in the learning environment: rectangular and circular tables for group meetings, comfortably supporting both individual and group learning; lockers to store individual belongings of students and teachers; individual chairs with different colors, organized in the U-shape; and a wall in the background that allows users interventions such as chalk use (figure 13). Strategies used to awaken protagonism and support individual needs; in addition to continuing to offer the white board of notes, the projector and the teacher's desk with a computer (figures 14 and 15).

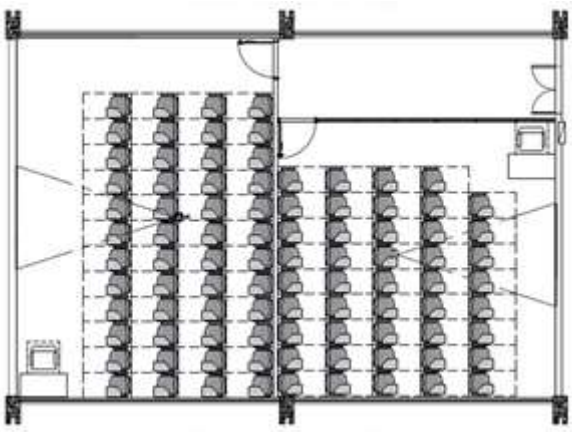

Figure 12. Standard UNEB traditional classroom model

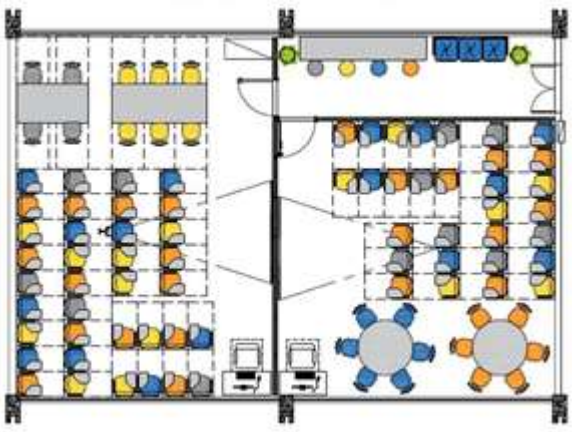

Figure 13. Proposed DEES learning environment

Figure 14. Group tables and colored chairs

Figure 15. Wall for user interventions

However, the biggest difference in this project is the incorporation of a support area for students deployed in the circulation area, which offers a desk for task development, research and group meetings, and a sofa for relaxation (Figure 16). In addition to enabling the integration between learning environments with the use of retractable partitions, making the environment design more flexible from the pedagogical needs (Figure 17).

Figure 16. DEES relaxation zone

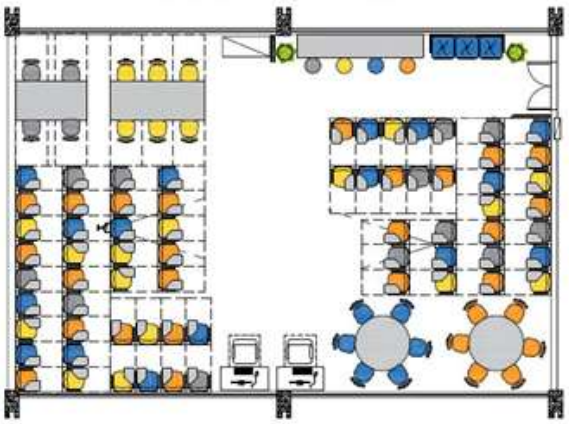

Figure 17. Integration of DEES learning environments

The maturation coming from the development of the MandacaruLab project alongside with the proposal of the Learning Environments for the DEES, instigated this research to seek new contemporary theoretical foundations that could help to evolve the learning environment model for UNEB.

Therefore, following the principles of the theory of active methodologies, this research absorbs the theory of Neuroeducation (TOKUHAMA-ESPINOSA, 2008), which highlights the importance of physiological issues of human nature in learning processes. Towards this physiology for the development of pedagogical practices directed this research to also include the theory of Neuroarchitecture (SUSSMAN; HOLLDEN, 2021), which studies precisely the human physiological responses to the stimuli of the built environment.

New theoretical references enabled the evolution of the presented projects, originating preliminary studies of the project for the Learning Environment Model for Higher Education (LEMHE), initiated in 2021.

4. Discussion

To develop the LEMHE proposal, the standard design of the existing classrooms at UNEB was used as a basis. Those particularly located on the ground floor, possible to be connected with outdoor green areas.
Seeking to evolve the classroom project from the experiences acquired with the projects of the MandacaruLab and the rooms of the DEES, added to the new guidelines coming from the principles of the theories of Neuroeducation, taken from the work of Tokuhama-Espinosa (2008): enabling experience with different ways of learning, supporting social interactions as well as providing privacy, providing a place for rest; deploying small snacks that can support moments of social relaxation, control the propagation of sound; establish satisfactory levels of lighting, acoustics, and ventilation that enable students and teachers to properly visualize each other's faces, voice tone control, and adequate oxygen availability for users of the environment, and planning an environment that stimulates positive emotions; and from Neuroarchitecture, inspired from the research in cognitive architecture developed by Sussman and Hollden (2021): stimulate movement, protect the backs of users, organize the environment in a way to preserve symmetry, prioritize furniture with curved lines, use in the decoration of the environment intermediate patterns of fractals, provide visibility between the internal and external environments, stimulate the protagonism in the organization of the environment and the exposition of narratives, use colors that stimulate positive emotions, provide direct, indirect, and spatial experiences with nature (natural materials, openings that enable the vision of the external nature and natural illumination, in addition to bringing nature to the internal environment with natural vegetation, and shapes that refer to nature).
Incorporating the guidelines, the Model preliminary proposal begins with the division of the environment into three learning zones: flexible zone (active); introspection zone, and relaxation zone (Figure 18).
This zoning is intended to simplify the understanding of the environment from the intended learning experiences. In this way it is possible to provide experiences to share, interact, create, investigate, and develop, focus for the zoning of MandacaruLab, in all three proposed zones.

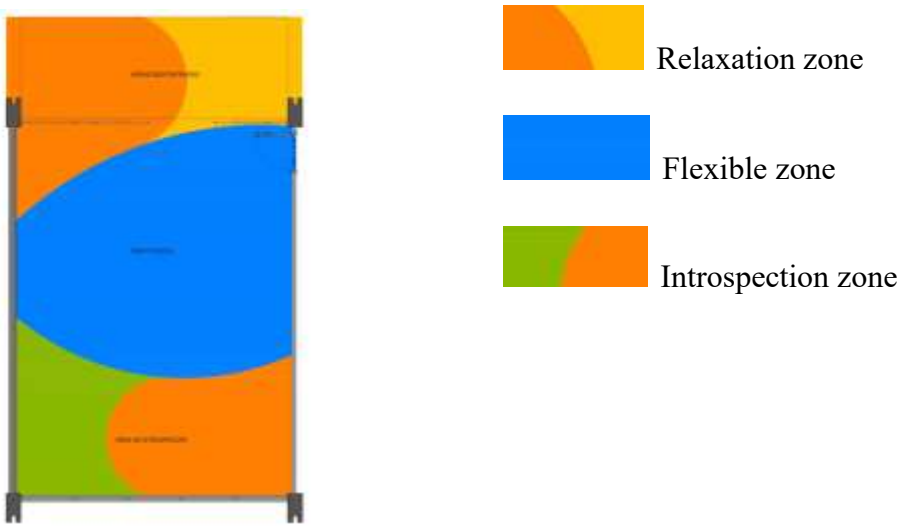

Figure 18. Zoning of the UNEB learning environment model

The introspection zone is directed towards a more private and individual learning, structured with three furniture: the research table, the sofa, and the armchairs with the individual tables (Figure 19). Designed

using the following strategies to encourage peace of mind and welcoming in this environment:

(1) Adopt the colors orange, green and wood highlighted. The orange, for furniture intended for moments of introspection, such as the sofa and armchairs; and the shades of green and wood, referring to the biophilic connection with nature to stimulate tranquility, used at the research table that, also offers direct contact with nature with the presence of a bush in the center;

(2) The design of the sofa and its soft texture intended to welcome, and the modular poufs can expand the area for greater comfort or be used individually;

(3) It is located near to the external openings to allow visibility and establish more privacy for the active area, since the proposal is to unlock the frames.

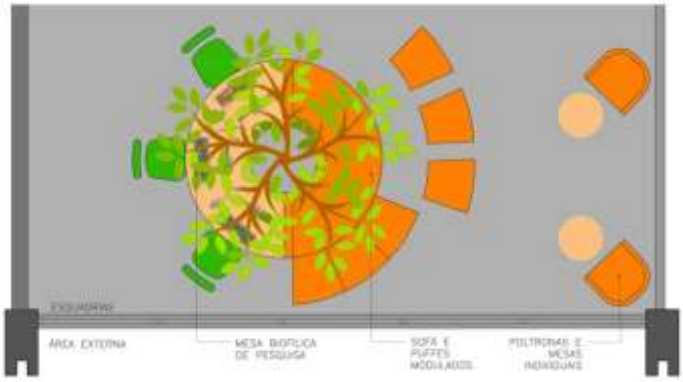

Figure 19. Introspection zone

The active zone is characterized by flexibility, created to offer several layouts for the different active pedagogical practices (Figure 20). These characteristics were implemented in the project with the definition of the following architectural strategies:

(1) Specification of furniture (tables, chairs, and white board) with wood finish, referring to the connection with nature. They should also have wheels, possible to be stacked; easy to handle, and articulate allowing group practices (larger and smaller), and lectures with specialist;

(2) Highlight the blue color in the chairs, to stimulate connection between the active environment and its users through the feeling of sympathy, harmony, and fidelity;

(3) Prioritise tables with modular formats that establish a captivating complexity in the user and refer to curves and circles;

(4) Arrange the tables and chairs in a way that frees the circulation at the edges and provides protection of the users' backs.

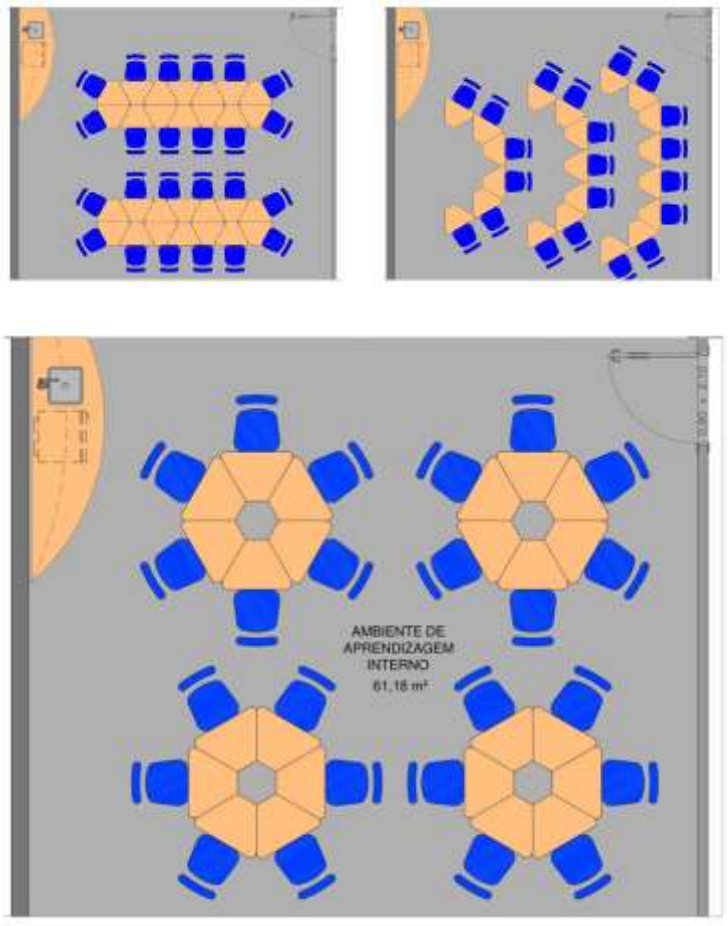

Figure 20. Flexible Zone (active)

The decompression zone is designed to meet the physiological needs of users. It comes with the incorporation of a balcony that connects the external nature to the learning environment, referring to relaxation (Figure 21). For this, the strategy used was to establish three furniture: A counter for the pantry, hammock, and outdoor lounge.

(1) The counter will be used as a small pantry to support the consumption of small snacks, with electrical structure to receive coffee maker, refrigerator, and hydraulic for a small sink. Strategically located at the intersection of the decompression zone and the active zone, to offer support during pedagogical practices, and in social events of relaxation.

(2) Provide the hammock to support the need for rest and introspection, therefore also prioritizing the use of orange color;

(3) Create an external lounge that functions as a living room, where people meet, interact, and enjoy social relationships. Prioritizing the use of wood as material and offer a garden with yellow flowers that refer to relaxation.

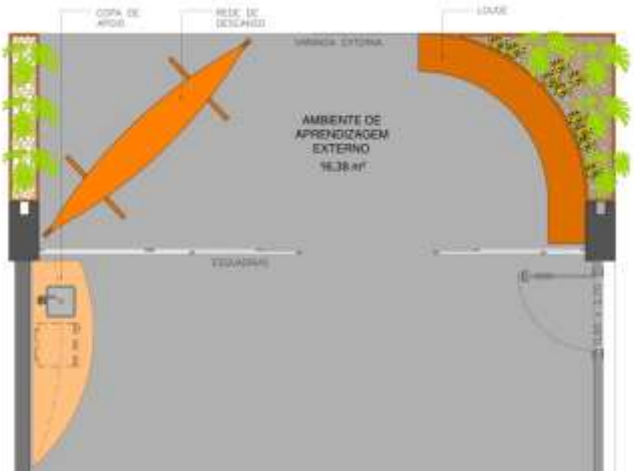

Figure 21. Decompression zone

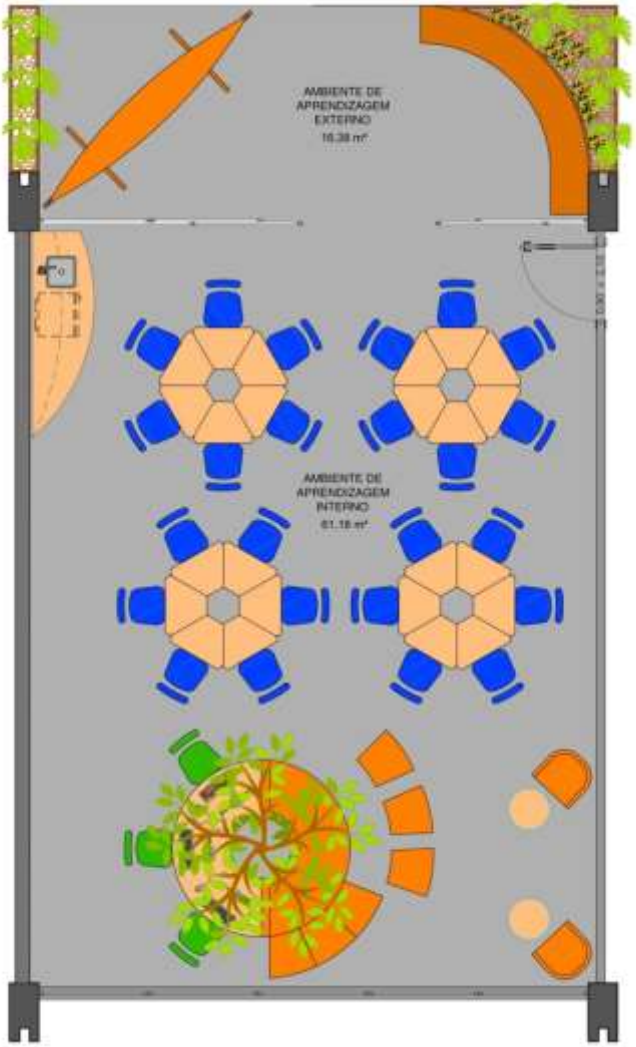

Figure 22. LEMHE Low Layout Plant – UNEB

5. Conclusion, Heading Level-1.

The awareness of the problem addressed, which is already being treated with constancy by several pedagogues among them José Pacheco (2017) considers that: "the education of the 21st century is

commanded by teachers of the 20th century, in a physical structure of the 19th century", leads to the survey of guidelines and strategies for the design of a new architectural model of learning environment for higher education: which dialogues with the contemporary social, technological, and cultural context, in an attempt to break with the historical traditionalism of these institutions. This path represents a perspective of transformation of higher education at UNEB, which can become a reference for other universities in Brazil and in the world.

6. Acknowledgement

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