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The (de)construction of confort teaching in architecture schools:

THE CASE OF LIGHTING EDUCATION

Federal University of Rio Grande do Sul
Faculty of Architecture
Research and Postgraduate Program in Architecture

The (de)construction of comfort teaching in architecture schools: the case of lighting education

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Doctoral Thesis submitted to the Graduate Program in Architecture at the Federal University of Rio Grande do Sul as a final requirement for obtaining the Doctor of Architecture (PhD) degree with a concentration in Architectural and Urban Design.

Advisor: Prof. Betina Tschiedel Martau, Ph.D.

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ABSTRACT

Lighting and its effects have been significant topics of discussion in various fields, such as architecture, engineering, performing arts, medicine, biology, and physics. However, in the educational realm of architecture professionals, few records discuss teaching methods, learning assessments, and program descriptions, indicating a research gap, especially in fundamental courses in Architecture and Urbanism, such as project studios. This thesis aims to contribute a teaching practice that integrates lighting and project design in Brazilian architecture and urbanism schools. By doing so, it aims to contribute to the professional education that will enhance the quality of life for users through their projects. Lighting education in architecture courses can be naturally reflected from different perspectives. The premise of this work recognizes a gap between various knowledge sources that constitute an architect's education and the lack of a consistent structure to connect them. This research hypothesizes that it is possible to teach lighting in architectural and urban planning courses in a way that students develop the competence to design while considering light behavior in both internal and external spaces. Despite the many possible pathways contributing to professional education, it is believed that teaching through project-based practice is one of the most effective strategies. The research is based on theoretical and documentary research, surveys with architects, interviews with professors, and approaches with Italian and Brazilian students. It incorporates Donald Schön's reflective practice theory, emphasizing collaborative practice, reflective evaluation, continuous learning, and innovative problem-solving. By exploring case studies and fieldwork, this study identifies insights contributing to the critique of pedagogical practices and teaching strategies, highlighting the importance of an integrated educational approach. These observations aimed to understand student interactions with architectural lighting education and to assess the strategies and challenges faced teaching and learning processes. The results indicate that students initially had limited practical knowledge about lighting, as evidenced by a survey conducted at the beginning of the course. However, after implementing integrative exercises and reflective practice principles, students' understanding and confidence in lighting design improved significantly. The practical application of theoretical knowledge allowed students to engage critically with the content, fostering a deeper understanding of lighting's role in architectural design. The results for Professors also identified various teaching methodologies, didactic resources, software, and other particularities. In conclusion, this thesis proposes didactic-pedagogical contributions to improve the integration of lighting content with project practice through reflective analysis. It emphasizes the importance of maintaining foundational comfort disciplines, introducing new software and experiential learning methodologies, and fostering a solid professor-student relationship. The study suggests that a comprehensive approach to lighting education, including technical and experiential learning, can significantly enhance the quality of architectural education and practice. Future research directions include exploring lighting education in different contexts, evaluating theorists from other educational areas discussing integrative themes, deepening the international context of Lighting education in architecture courses, and assessing student learning from various types of learning content. Overall, this thesis comprehensively analyzes lighting education in architecture, proposing innovative solutions to enhance teaching practices and student learning outcomes.

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LIST OF ABBREVIATIONS AND ACRONYMS

ABEA	*Associação Brasileira de Ensino de Arquitetura e Urbanismo* (Brazilian Association of Architecture and Urbanism Education)
CAU	*Conselho de Arquitetura e Urbanismo (*Council of Architecture and Urbanism)
CAPES	*Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (Coordination of Superior Level Staff Improvement)
CIE	*Comissão Internacional de Iluminação* (International Commission on Illumination)
DCNs	*Diretrizes Curriculares Nacionais* (National Curriculum Guidelines)
IEA	*Agência Internacional de Energia* (International Energy Agency)
LDB	*Lei de Diretrizes e Bases* (Law of Guidelines and Bases)
MEC	*Ministério da Educação* (Ministry of Education)
PPC	*Projeto Pedagógico de Curso* (Course Pedagogical Project)
PPP	*Projeto Político Pedagógico* (Pedagogical Political Project)
UFAL	*Universidade Federal de Alagoas* (Federal University of Alagoas)
UFAP	*Universidade Federal do Amapá* (Federal University of Amapá)
UFBA	*Universidade Federal da Bahia* (Federal University of Bahia)
UFG	*Universidade Federal de Goiás* (Federal University of Goiás)
UFPA	*Universidade Federal do Pará* (Federal University of Pará)
UFRGS	*Universidade Federal do Rio Grande do Sul* (Federal University of Rio Grande do Sul)
UFRJ	*Universidade Federal do Rio de Janeiro* (Federal University of Rio de Janeiro)
UFSC	*Universidade Federal de Santa Catarina* (Federal University of Santa Catarina)
UFSM	*Universidade Federal de Santa Maria* (Federal University of Santa Maria)
UnB	*Universidade de Brasília* (University of Brasília)
USP	*Universidade de São Paulo* (University of São Paulo)

SUMMARY

1 INTRODUCTION

Light, in its essence, possesses factors and responses that directly affect human beings. According to Houser *et al.* (2021), the nature of this response can vary from physiological, perceptual, and psychological to behavioral aspects. Tanriöver and Şansal (2017) state that our well-being and quality of life depend on successfully integrating natural and electric light into the built environment. Additionally, Matos (2023) asserts that the main challenge for including daylight in the design process lies in sensitizing the architect to use light and preparing them to transcend purely quantitative issues, exploring the possibilities it offers to transform architectural space. Thus, understanding lighting as a fundamental aspect applied to design at various scales is essential in educating an Architecture and Urbanism professional. These knowledge areas are developed and built during higher education through the development of skills and competencies. Freire (1996) states these are not acquired by simple "transfer" but from the possibility of knowledge production. Supporting this idea, Bondía (2002) argues that there is a sharp difference between knowledge and information, with knowledge acquired through experience and construction, while information can be transferred superficially by various means. Perrenoud (1999) states that the development of competencies should be encouraged over the transmission of knowledge to contribute to learning by doing and critical reflection on the obstacles encountered in the learning process. This emphasis on critical reflection underscores the importance of self-evaluation in the learning process.

The discussion on knowledge construction and teaching practices is the theme of this doctoral thesis, focusing on the Architecture and Urbanism course, specifically on subjects that deal with lighting education. According to the Brazilian Association of Architecture and Urbanism Education (ABEA), the nature of training for the architect professional is collaborative, innovative, and creative, and can be built from these strategies for developing the educational environment. Corresponding to this formative nature, it can present the architect as a reflective professional, a term popularized by Donald Schön (2000), a theorist who will be a foundational reference for this research and who discusses learning through proficiency in a type of reflection-in-action, thus involving a dialogue between instructor and student that takes the form of reciprocal reflection. Schön's worldwide importance inspires changes in the field of education and the quality of his work, which considers the professor as a producer of knowledge and not merely an executor of tasks (Alberton, 2021). The major contemporary educational challenge is to address the intense process of dissolving the original unity of the human being between the theoretical and the practical, between the useful and the ethical, between the shapeless and the aesthetic, which isolates the epistemic, ethical, and aesthetic

dimensions from each other (Goergen, 2016). Montaner (2017) emphasizes that the meaning of architecture lies in its relationships with other fields, but this does not negate the fact that architecture has its specificity and its creative and intellectual moments of project synthesis. The author argues that it is necessary to reject some anachronistic concepts when they come from a closed, simplistic, and static culture. Rozestraten (2007) writes that architecture development, like other artistic activities, is engendered by the daily exercise of confronting the material. In other words, architecture is neither a discipline nor a science but represents a set of technical knowledge and instrumental skills in constant transformation (Montaner, 2017).

Continuing this thought about the autonomy and relationships of systems in the production and transformation of knowledge, **research problems** can be identified in what Kaminer (2011) calls the dilemma of the contemporary architecture student, beneath the pedagogical challenge, and invites architect-educators and, consequently, architecture disciplines to address this dilemma. The classroom is then viewed from two perspectives: one as a means of teaching and learning specific knowledge and content systematically, and another as a medium in which actions and interactions are established, not only restricted to the subject and knowledge or written materials but also involving interpersonal and intrapersonal relationships (Damis, 2010). In other words, all practices developed within the classroom materialize through the actions experienced and experimented with in human relationships. Architecture, as an art that configures spaces (Gadamer, 2015), points beyond itself, as it is an open book that allows for multiple and diverse interpretations. Thus, the inclusion of discussions regarding the integration of disciplines sometimes seen as complementary or even elective proves relevant to the set of constant transformations that schools of Architecture and Urbanism may experience. These transformations can, in some way, involve all agents participating in the system, such as professors, curricula, legislation, infrastructure, and students. **The relevance** of this research is justified by observing that the different axes of architecture and urbanism (project, reflection, representation, and technology) consider light as a fundamental factor. Le Corbusier, in his book "Vers une architecture" (1923), famously stated: "Architecture is the learned, correct, and magnificent play of masses brought together in light." Additionally, Nasybullina et al. (2021) affirm that the perception of an interior building's space is possible only if illuminated with daylight or artificial light. In urbanism, according to Maccheroni et al. (2021), it is essential to stimulate multidisciplinary collaboration in the lighting design of urban spaces with greater sensitivity, aimed at supporting urban trends on a human scale considering the built environment, people, and nocturnal ecosystem. In reflection (theory, criticism, and history), the role of light in theory and criticism, as well as in history, is explored through investigations into the qualitative nature of phenomena such as shadows and illumination across different cultures and periods using scientific tools and reasoning (Prendergast, 2022). In technology,

light plays a crucial role in architecture by influencing human perception, material interaction, and the creation of unique spaces through its illuminating properties. Designing with light in mind is essential for enhancing the effects of form, material, and color within a space (Cengiz, 2023). Thus, the following research question is formulated: “How can Architecture and Urbanism courses address the teaching of lighting in a way that structures and implements the development of competencies and reflective practices in students, preparing them to apply light in their projects better?”

This research explores theoretical perspectives on education within the context of Architecture courses without disconnecting from practical design. The study is also based on the arguments of Mahfuz (2003), who defines disciplinary knowledge in an Architecture and Urbanism course as the knowledge acquired through practical design, composed of theoretical, historical, and critical knowledge, which helps to avoid arbitrariness and results in the correct way of designing. Scarazzato (2018) also points out that the atelier is the locus par excellence for teaching lighting. According to Mizoguchi (2016), the atelier is where actions inherent to professional practice are simulated and where the teaching-learning processes directly related to the project, the essence of the architect's activity, are developed. Finally, Schön (2000) emphasizes sensitization, action, and reflection stages. Additionally, architectural theories and the poetics of light are considered, aiming to generate discussions about the teaching of lighting, (de)constructing it if necessary, and promoting the creation of educational practices to improve its quality.

The originality of this thesis is underscored by its unique approach. It provides an unprecedented perspective by interviewing Lighting professors in Architecture courses from eight different countries, considering diverse educational contexts. Furthermore, it offers insights rarely explored in existing literature by analyzing the curricula of Brazilian universities, highlighting pedagogical practices, and the integration of lighting in teaching programs. Finally, it develops a comprehensive and in-depth understanding of possible lighting teaching strategies by combining systematic observations in institutions like the Politecnico di Torino with direct engagement with UFRGS professors, promoting a critical analysis with significant contributions to Architecture education.

To develop this thesis, it was necessary to consider some initial assumptions as a starting point. The first pertains to the need for educating professionals capable of designing spaces where natural and electric light is applied as one of the basic premises of the design solution. Therefore, considering the teaching of light within the Architecture and Urbanism undergraduate course is fundamental. The second point relates to developing competencies for creative and innovative thinking through reflective practical education, the foundation of Donald Schön’s theory (2000): doing and reflecting on one's action with the professor's assistance. Lastly, **Brazilian research should be limited to public**

institutions that operate under university regulations and work on the three aspects of teaching, research, and extension, and on the international side, to institutions that stand out in some way in teaching lighting within architecture courses. The following **hypotheses** are thus constructed:

1. Lighting can be taught in architecture and urbanism project courses so that students develop the competence to design considering the behavior of light in internal and external spaces.

2. Although there are many possible paths to professional training, teaching through practical design is considered one of the most efficient strategies.

Regarding **scientific contributions,** this thesis develops pilot practices and evaluates established integrated lighting teaching practices to significantly contribute to educating professionals in handling lighting in their architectural projects. Qualitative and quantitative methods include interviews, questionnaires, document analysis, and systematic observation. Bricolage techniques are adopted for a comprehensive and complex data analysis. The thesis scientifically suggests new methodological and pedagogical approaches to lighting education by integrating various tools.

Regarding the **social contributions** of the research, it is understood that proposing improvements in practical design, making it reflective, and better preparing students to effectively apply lighting in their projects directly contributes to the quality of life of the users of the spaces they will design. Moreover, the proposed educational approach goes beyond transmitting technical knowledge, encouraging a critical and reflective process on the importance and impacts of lighting in **different social and cultural contexts**. Aligned with the principles of educational theorists, the research suggests collaborative and dialogical educational practices that promote student engagement and **social transformation through education.**

1.1 OBJECTIVES

1.1.1 General Objective

Critically discuss lighting education and its reflective relationships with architectural practice.

1.1.2 Specific Objectives

- Identify gaps in the teaching of lighting within undergraduate Architecture and Urbanism courses at a global level;
- Identify theoretical-pedagogical foundations of teaching-learning;

- Identify teaching-learning methodologies and didactic-pedagogical resources (conceptual and procedural) of environmental comfort, specifically in lighting;
- Identify the integration relationships between the teaching of lighting and architectural design education;
- Discuss how Donald Schon's theories may relate to lighting education.
- Propose didactic-pedagogical contributions to improve the integration of lighting content with design practice through reflective analysis.

Below is a coherent framework [1] of the thesis, clearly detailing the objectives, their secondary questions, and research techniques.

Table 1 - Thesis coherence framework

Theme: The (De)construction of Comfort Education in Architecture Schools: The Case of Lighting Education, i.e., a critique of lighting education among professors, architects, curricula, and students.		
Problem: (1) How can Architecture courses address the teaching of lighting in a way that structures and implements the development of competencies and reflective practices in students, preparing them to apply light in architectural projects better? (2) In what way does the reflective and practical approach in lighting education contribute to the development of design competencies in Architecture and Urbanism students?		
General Objective: Critically discuss lighting education and its reflective relationships with architectural practice.		
Secondary questions	**Specific Objectives**	**Research Techniques**
What are the main gaps in the teaching of lighting in undergraduate Architecture and Urbanism courses?	(1) Identify the gaps in the teaching of lighting within undergraduate Architecture and Urbanism courses;	(1) Bibliographic research; (2) Systematic literature review; (3) Document analysis (curricular);
What are the most relevant theoretical-pedagogical foundations for the teaching-learning of lighting in Architecture? And how does this happen, considering its constraints?	(2) Identify theoretical-pedagogical foundations of teaching-learning.	(1) Bibliographic research; (2) Systematic literature review; (3) Document analysis.
What methodologies and didactic pedagogical resources are used for teaching and learning about lighting?	(3) Identify the methodologies and didactic-pedagogical resources (conceptual and procedural) for teaching-learning in environmental comfort, specifically lighting;	(1) Document analysis (curricular); (2) Interviews.
How is the integration between the teaching of lighting and the teaching of architectural design in Architecture and Urbanism courses carried out?	(4) Identify the integration relationships between the teaching of lighting and the teaching of architectural design;	(1) Field research in Brazil and Italy; (2) Application of experimental exercises with students.
How can Donald Schön's theories be applied to the teaching of lighting in Architecture courses?	(5) Discuss how Donald Schon's theories may relate to the teaching of lighting;	(1) Bibliographic research on Schon's theories; (2) Categorization and final analysis of field research data.

[1] A coherence framework is a tool used to promote consistency among the elements that make up the writing of a scientific work, whether it is an article or a research project (Kochhann, 2021).

What main didactic-pedagogical contributions can be proposed to improve the integration of lighting content with design practice through reflective analysis?	(6) Propose didactic-pedagogical contributions aimed at improving the integration of lighting content with design practice through reflective analysis;	(1) Categorization and final analysis of data.

Source: Prepared by author.

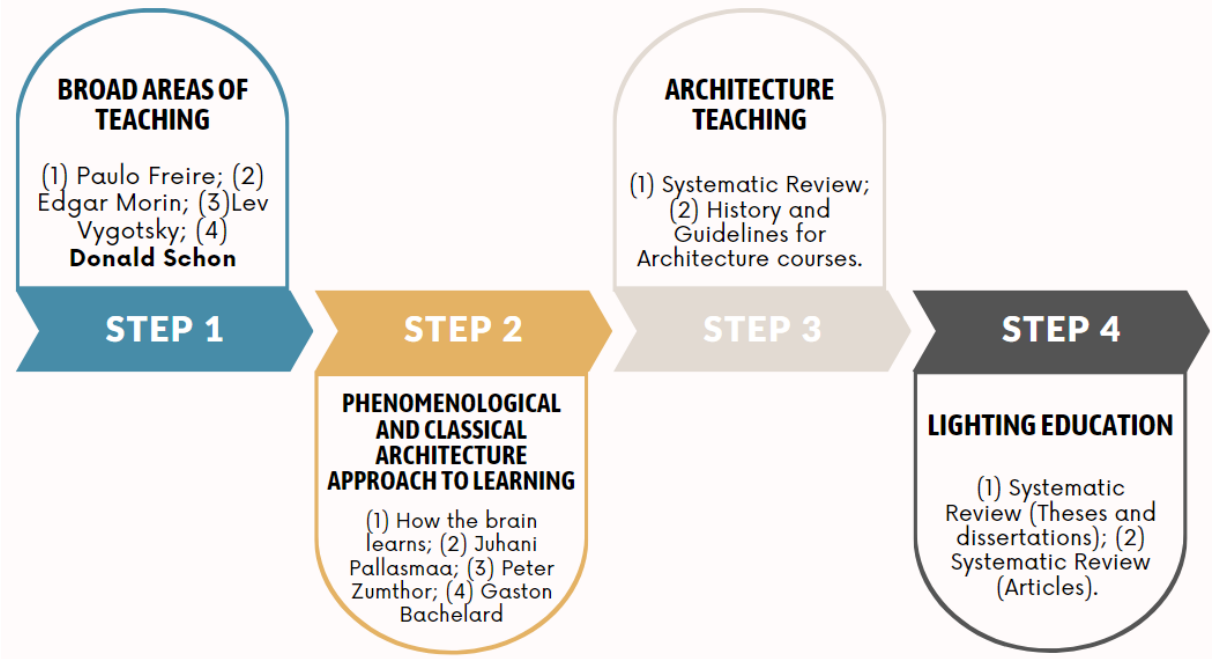
1.2 THESIS STRUCTURE

This thesis is structured into several interconnected sections that collectively provide a comprehensive understanding of the topic. First, the **introduction presents the theme, justifies the study's relevance by highlighting the gap in the area, outlines the problem, assumptions, and hypotheses, and defines** the scope of the research. The Literature Review, titled **Theoretical Approach**, examines pertinent studies and theories on lighting education, offering critical analysis and identifying gaps in the existing literature. Next, the **Methodological** Path details the research methods used, addressing qualitative and quantitative techniques and the sequence of procedures performed to meet the proposed objectives. The section **Approach with Graduates and the University** analyzes: (1) how graduates active in the professional market evaluate lighting education; (2) the curricula of Architecture and Urbanism courses at public institutions in Brazil; (3) interviews with faculty members about methods and practices of lighting education, discussing the results obtained. The **Approach with Students** describes the practical activities applied to students, reflecting on the effectiveness of the pedagogical practices. The **Data Cross-Referencing** section integrates the information obtained from different approaches, providing a comparative analysis and interpretation of the results, as well as discussing the implications of the findings. Finally, the **Conclusion** synthesizes the main findings of the research, reflecting on the contributions to the field of lighting education and proposing directions for future research and improvements in teaching.

2 THEORETICAL APPROACH

The literature review chapter was divided into four parts (Figure 1) to provide a comprehensive overview of the areas discussed. This chapter established the foundation for the stages by drawing on theoretical, historical, and practical principles and integrated these perspectives for a thorough analysis.

Figure 1 - Flowchart



Source: Prepared by author.

2.1 BROAD AREAS OF TEACHING

This section discussed several education theorists whose theories contributed to the foundation of integrative teaching practices. To understand possible forms of integration and constructivist teaching methodologies, theorists such as Donald Schön, Paulo Freire, Edgar Morin, and Lev Vygotsky were chosen. A concise overview of each theorist's perspectives was presented, and it was demonstrated which concepts could enhance the quality of teaching in Architecture and Urbanism.

2.1.1 Paulo Freire

Paulo Freire, a Brazilian educator and philosopher, is widely recognized for his significant contributions to critical pedagogy. Freire (1970) proposed an educational approach that transcends mere knowledge transmission, emphasizing dialogue, awareness, and social transformation. His theory suggests that

education should be an act of freedom and a collaborative process in which professors and students learn mutually. According to Freire, education does not transform the world. Education changes people. People transform the world (Freire, 1970). Freire's pedagogy is grounded in three main concepts: **dialogue, conscientization, and problematization.** For Freire, dialogue is the foundation of liberating education, where the educator ceases to be the holder of knowledge and becomes a facilitator of learning. This dialogical process is essential for promoting awareness, or "conscientization," through which students develop a critical understanding of their social and economic reality (Freire, 1996).

According to McLaren (2000), Freire challenged the traditional model of 'banking education,' where students are seen as passive recipients of knowledge. In contrast, he proposed a participatory and critical educational model, encouraging students to question, reflect, and act upon their reality. Giroux (1988) reinforces Freire's pedagogy is a pedagogy of hope and possibility, transforming education into a practice of freedom. In the context of lighting education, the application of Paulo Freire's theory can potentially transform how this knowledge is transmitted and assimilated significantly. Traditionally technical and skills-focused, lighting education can be invigorated by an integrative approach incorporating Freirean pedagogy principles. This approach conveyed technical knowledge and engaged students in a critical and reflective process regarding the importance and impacts of lighting in different contexts, inspiring a new generation of lighting professionals.

Discussions about how lighting affects human well-being, sustainability, and social relations aligned directly with Freire's points. For example, active participation in creating projects that address real problems promotes a deeper and more meaningful understanding of lighting's role in their lives and community relationships. This approach fostered problematization, encouraging students to identify and analyze issues related to lighting and develop creative solutions. According to Freire (1996), problematization is an essential process that allows students to question reality and transform it through critical and reflective action. Furthermore, dialogue as a pedagogical practice can be implemented through workshops, debates, and collaborative projects, where students share their experiences and perspectives on lighting. Freire (1970) states that dialogue is an encounter between people, mediated by the world, to designate it, emphasizing the importance of educational practices that promote open communication and the exchange of ideas.

Studies by Veitch (2012) on sustainable lighting suggest that collaborative projects increase creativity and innovation and promote greater student engagement in seeking environmentally responsible solutions. By adopting a Freire approach, educators can transform lighting education into a dynamic and participatory process, preparing students to be agents of change in their communities and

professions. According to Boyce (2014), lighting education that involves active student participation can lead to a better understanding of sustainable lighting principles and their impact on well-being and health.

Freire's ideas find significant parallels with the approaches of Walter Gropius and Edgar Dale. Gropius, the founder of the Bauhaus, emphasized integrating theory and practice, similar to Freire's dialogical approach, where collaborative practice is essential for learning (Gropius, 1965). On the other hand, Edgar Dale, with his "Cone of Experience," proposed that direct and practical experiences are fundamental for effective learning, complementing Freire's emphasis on education through real and relevant experiences (Dale, 1969).

2.1.2 Edgar Morin

Edgar Morin is a sociologist, philosopher, and writer known for his complex and interdisciplinary approach to society and human thought. He has authored several books on the **theory of complexity.** Two of his works have been used as a basis for this research: "The Seven Complex Lessons in Education for the Future" (Morin, 2000a) and *"La Tête Bien Faite"* (Morin, 2000b).

Morin's theory of complex thought posits that reality is multidimensional and interconnected; therefore, knowledge should be approached in a transdisciplinary manner. Morin (1999) argues that pertinent knowledge must recognize and address complexity (Morin, 1999, p. 19). He **criticizes the fragmentation of knowledge into isolated disciplines,** arguing that this leads to a limited and distorted view of reality. Instead, Morin suggests an approach that integrates different areas of knowledge, recognizing the interactions and interdependencies among the various aspects of reality.

According to Morin (2002), complex education should address the seven essential lessons for the future of education: the blind spots of knowledge, the principles of pertinent knowledge, teaching the human condition, teaching planetary identity, confronting uncertainties, teaching understanding, and the ethics of the human race. These lessons aim to provide an education that enables individuals to understand and act in the world consciously and responsibly.

Morin's complex thought is supported by various studies. According to Araújo (2005), Morin offers an alternative to the fragmentation of knowledge by proposing a form of thinking that integrates and articulates different areas of knowledge. Gutiérrez (2013) also emphasizes that Morin's approach is essential for addressing contemporary challenges, characterized by their complexity and interconnectedness.

Applying Edgar Morin's theory can significantly transform how this knowledge is transmitted and understood in lighting education. Traditionally, lighting education has been dominated by a technical

and segmented approach, focused on specific aspects such as the physical principles of light, lighting technologies, and safety standards. However, to more effectively address contemporary challenges, it is crucial to adopt an integrative approach, as proposed by Morin.

Integrative lighting education should consider not only technical aspects but also the social, cultural, environmental, and ethical contexts in which lighting is applied. Gutiérrez (2013) states, “Integrating different areas of knowledge allows for a deeper and more critical understanding of complex issues.” This can include case studies on public space lighting, sustainable lighting projects, and analyzing how different communities are affected by lighting practices. An integrative approach in lighting education should promote transdisciplinarity, encouraging collaboration among disciplines such as architecture, design, engineering, psychology, and environmental studies. Morin (1999) asserts that “transdisciplinarity is essential for understanding the complexity of the contemporary world.”

Morin's vision finds significant resonance in the ideas of Christopher Alexander, especially in his work "A Pattern Language." Alexander proposes that design should be user-centered and approached holistically, considering not only technical aspects but also behavior patterns and fundamental human needs. He suggests that the creation of spaces should be guided by a pattern language that integrates various disciplines and knowledge (Alexander, 1977). Alexander's methodology, which emphasizes collaboration and intuition in creating functional and aesthetically pleasing environments, complements Morin's theory of complexity. Both advocate for an integrative and transdisciplinary approach to education and design processes. Just as Morin (1999) calls for an education that recognizes the complexity and interconnection of the world, Alexander (1977) proposes a design system that reflects this complexity by integrating different aspects of human knowledge.

2.1.3 Lev Vygotsky

Lev Vygotsky was a psychologist whose contributions to developmental psychology and education are highly influential, particularly his sociocultural theory of cognitive development. Vygotsky proposed that social and cultural interactions fundamentally mediate intellectual development**.** His sociocultural theory emphasizes that individuals' cognitive development is profoundly influenced by their **social interactions** and the cultural environment they are part of. He introduced vital concepts such as the "zone of proximal development" (ZPD), which refers to the difference between what a child can do alone and what they can do with the help of an adult or a more experienced peer. Vygotsky (1978) argues that learning triggers various internal developmental processes that can only operate when a child is interacting with people in their environment and cooperating with their peers (Vygotsky, 1978, p. 90).

In teaching lighting in architecture, the concept of ZPD can be applied to create a dynamic and collaborative learning environment. Through supervised practical activities and group projects, students are encouraged to explore and apply lighting concepts beyond their current capabilities but with the necessary support from instructors or more experienced peers. For example, when working on lighting projects for natural architectural spaces, students can receive direct guidance on selecting and positioning lighting equipment, adjusting color temperatures, and creating specific lighting atmospheres. Additionally, using technological tools, such as lighting simulation software, allows students to visualize and experiment with different lighting scenarios in a controlled environment. This teaching method not only enriches technical learning but also encourages a deeper understanding of the aesthetic and functional implications of lighting in architectural spaces, promoting a gradual transition from dependence on support to professional autonomy.

Another fundamental contribution of Vygotsky is emphasizing semiotic mediation, where cultural tools, especially language, play a crucial role in cognitive development. For Vygotsky, language is the primary tool of thought, and through it, social interactions shape cognition. Semiotic mediation refers to using signs, symbols, and other forms of cultural representation to mediate understanding and knowledge development. In lighting education, this mediation is crucial for translating abstract concepts into tangible and understandable student experiences.

Applying semiotic mediation in lighting education can involve many tools, including technical diagrams, specialized language, lighting design software, photography, and visual art. For example, diagrams and graphical representations can help illustrate light distribution in a space, showing how different light sources interact with architectural elements. Simulation software enables students to virtually explore the effects of different lighting configurations, allowing safe and effective experimentation before physical implementation. The technical language specific to the lighting field, such as terms describing lamp types, color temperatures, and luminous intensities, is a semiotic tool that enables precise and efficient communication between professionals and students. Moreover, using audiovisual resources, such as videos and photos of lighting installations, can provide a more intuitive and immediate understanding of the effects of lighting in different environments. These tools help mediate knowledge by connecting theory and practice, allowing students to visualize how the concepts learned apply in real-world contexts.

Semiotic mediation is also fundamental in developing students' ability to critically analyze and create lighting solutions. By learning to use and interpret signs and cultural tools correctly, students are empowered to think critically and creatively, considering not only technical but also aesthetic and symbolic aspects of lighting. This is especially important in lighting projects for architectural spaces,

where light serves a practical function and contributes to the atmosphere and meaning of the space. Thus, semiotic mediation in lighting education promotes a learning approach that is both technical and cultural, empowering students to become versatile professionals aware of the impact of their design choices. As Kozulin (2003) suggests, mediation through cultural tools, including technology, is essential for learning and cognitive development (Kozulin, 2003, p. 15). Lighting education can benefit from the sociocultural approach by including diverse cultural and social contexts in learning activities. This can involve lighting projects that consider different communities' specific needs and characteristics, promoting a more holistic and inclusive understanding of lighting. Gredler (2009) emphasizes that Vygotsky's sociocultural theory offers a valuable perspective for creating learning contexts that are socially and culturally relevant (Gredler, 2009, p. 45).

Vygotsky's ideas find significant parallels with the approaches of John Dewey and Howard Gardner. John Dewey, like Vygotsky, emphasized the importance of the social and cultural context in learning. Dewey advocated "learning through experience" and the central role of the educational environment in providing experiences that promote intellectual and social development (Dewey, 1938). Both theorists view learning as an active and interactive process **where collaboration and reflection play crucial roles**. Howard Gardner, known for his "Multiple Intelligences" theory, complements Vygotsky's view by recognizing the diversity of individuals' cognitive abilities. Gardner proposed that teaching should be adapted to leverage different forms of intelligence, such as spatial, logical-mathematical, and interpersonal (Gardner, 1983). Integrating Vygotsky's and Gardner's ideas can enrich lighting education by addressing the diversity of students' learning styles and promoting an inclusive and **collaborative learning environment.**

Finally, promoting collaboration between students and professionals in the lighting field can create a network of mutual support and learning, reflecting the principle that social interactions mediate cognitive development. Newman and Holzman (1993) argue that learning as a social and collaborative process is central to Vygotsky's vision of development (Newman & Holzman, 1993, p. 38). Thus, in the atelier's locus, both socialization as a tool for learning light in design and the cultural development of students can be applied.

2.1.4 Donald Schon

Donald Schön was an influential theorist and educator in learning and reflective practice. He is known for his contributions to organizational learning theory and professional practice. He is best known for his works "The Reflective Practitioner" (1983) and "Educating the Reflective Practitioner" (1987), in which he emphasized the importance of reflection-in-action as a central feature of professional practice.

Schön argues that professionals face uncertainty, instability, and complexity that cannot be resolved solely with traditional techniques and formal scientific knowledge. He introduces the concepts of "reflection-in-action" and "reflection-on-action" to describe how professionals handle unique and complex problems. Reflection-in-action refers to thinking while acting and adjusting actions based on emerging circumstances. In contrast, reflection-on-action involves reviewing and analyzing past actions to improve future practice (Schön, 1983). Eraut (1994) highlights that reflection-in-action enables professionals to act with greater confidence and effectiveness in situations of uncertainty and complexity (Eraut, 1994, p. 145). According to Boud et al. (1985), reflective practice is an essential process for continuous learning and professional development (Boud et al., 1985, p. 19).

When applied in the context of lighting education, Donald Schön's theory offers a practical approach to preparing students to face the field's challenges. By integrating reflective practice into the lighting curriculum through problem-based learning (PBL) projects, students can be equipped to solve real-world lighting problems. These projects provide a platform for students to practice reflection-in-action, adjusting their approaches as new information and challenges arise. Furthermore, activities such as reflective portfolios, learning journals, and feedback sessions can be used to promote reflection-on-action. These activities not only encourage students to review and analyze their experiences but also prepare them to identify areas for improvement and consolidate their learning. As Schön (1987) suggests, practitioners reflect in action while performing their tasks, allowing them to continuously adjust and improve their practices (Schön, 1987, p. 26).

Zeichner and Liston (1996) assert that reflection-on-action is crucial for continuous professional development, enabling practitioners to learn from their experiences and improve their practices (Zeichner & Liston, 1996, p. 47). Moreover, reflective practice can be applied integratively in lighting education by encouraging students to consider lighting's social, cultural, and ethical aspects. For example, when designing a lighting system for a community, students can reflect on how their choices impact the users' quality of life. Dewey (1933), a precursor of ideas on reflection in education, emphasized that reflection involves not only thinking about what we do but also considering the impact of our actions on the world around us (Dewey, 1933, p. 35).

Donald Schön's theory can be understood in seven essential points from the discussions presented. First, **collaborative practice** is fundamental, where interaction between students and mentors enriches the learning process. Next, **reflective evaluation** allows those involved to critically analyze their practices and developments, promoting a deeper understanding. **Lifelong learning** is a pillar, encouraging constant updating and adaptation to new trends and technologies. **Setting goals for reflective practice** is crucial to direct efforts and measure progress. **Innovative problem-solving** is a

differentiator that stimulates creativity and searches for new approaches. **Experiential learning,** where practice and theory complement each other, is essential for consolidating knowledge. Finally, **integrative practice** is key, uniting diverse knowledge and skills to form more complete professionals prepared for market challenges. Schön (1983) emphasizes that the reflective practitioner continually learns and improves, capable of facing new challenges with flexibility and creativity (Schön, 1983, p. 295).

David Kolb, known for his "Experiential Learning" model, complements Schön's theory by highlighting the importance of the learning cycle, including concrete experience, reflective observation, abstract conceptualization, and active experimentation. Kolb (1984) proposes that learning is a continuous process where each experience contributes to developing students' knowledge and skills. Similarly, Henry Sanoff, a pioneer in participatory education in architecture, also offers a complementary view to Schön's. Sanoff developed methodologies that involve end-users in the design process, emphasizing participatory and collaborative design (Sanoff, 1990). This approach can be applied to lighting education, promoting collaboration between students and professionals in the field and involving the communities affected by lighting projects.

Thus, exploring the theories of Paulo Freire, Lev Vygotsky, Donald Schön, and Edgar Morin provides an understanding of how education and cognitive development relate through reflective, collaborative, and integrative approaches. These thinkers emphasize the importance of the social, cultural, and ethical context in the learning process. Applying these principles to the field of architecture, especially in lighting education, encourages the creation of a learning environment that transmits technical knowledge and fosters creativity, critical reflection, and social responsibility.

This theoretical integration is essential when considering the phenomenological and classical approaches in architecture, which also value human experience, sensory perception, and the interconnection of spaces with their respective cultures. Phenomenology in architecture, for example, emphasizes the importance of subjective experience and the lived experience of space, aspects that are complemented by educational theories that promote learning through experience and reflection. Thus, the following section discusses the relationships and theories involving these different approaches.

2.2 PHENOMENOLOGICAL AND CLASSICAL APPROACHES IN ARCHITECTURE

The classical and phenomenological approaches to lighting education represent two extremes on the educational spectrum, each with specific characteristics, objectives, and methodologies. The classical

approach to lighting education is traditionally centered on the technical and scientific aspects. This approach emphasizes technical knowledge, safety standards, the physical principles of light, and available lighting technologies. The primary focus is ensuring students acquire the practical and theoretical skills to design and implement efficient and safe lighting systems. This approach provides a comprehensive introduction to the principles and practices of lighting, addressing essential technical and functional aspects of lighting design in various architectural contexts (Miller & Davis, 2012). The classical approach is based on objectivity and quantification, using measurable data and established standards to guide the design process.

In contrast, the phenomenological approach to lighting education focuses on light's subjective and qualitative experience. It is based on phenomenological philosophy, which seeks to understand how we perceive the world around us. This approach explores how lighting affects human perception, the environment, and well-being. Phenomenology considers light not just as a physical phenomenon but as an element that interacts with emotions, sensations, perceptions, psychology, and culture. Pallasmaa (2005) explores the importance of the senses in architecture, including the visual sense, its relationship with lighting, and how it affects human perception and experience in the built environment. He emphasizes that light is not just a matter of visibility but a tool for creating atmospheres and evoking emotions.

Zumthor discusses how light, along with other architectural elements, creates atmospheres that emotionally influence the occupants of a space. His approach is profoundly phenomenological, focusing on the subjective experience of light (Zumthor, 2006). Steven Holl, along with Juhani Pallasmaa and Alberto Pérez-Gómez, explores phenomenology in architecture, emphasizing how light and space are perceived and experienced by users, proposing an approach that integrates sensory perception with an understanding of architectural space (Holl, Pallasmaa, & Pérez-Gómez, 2006).

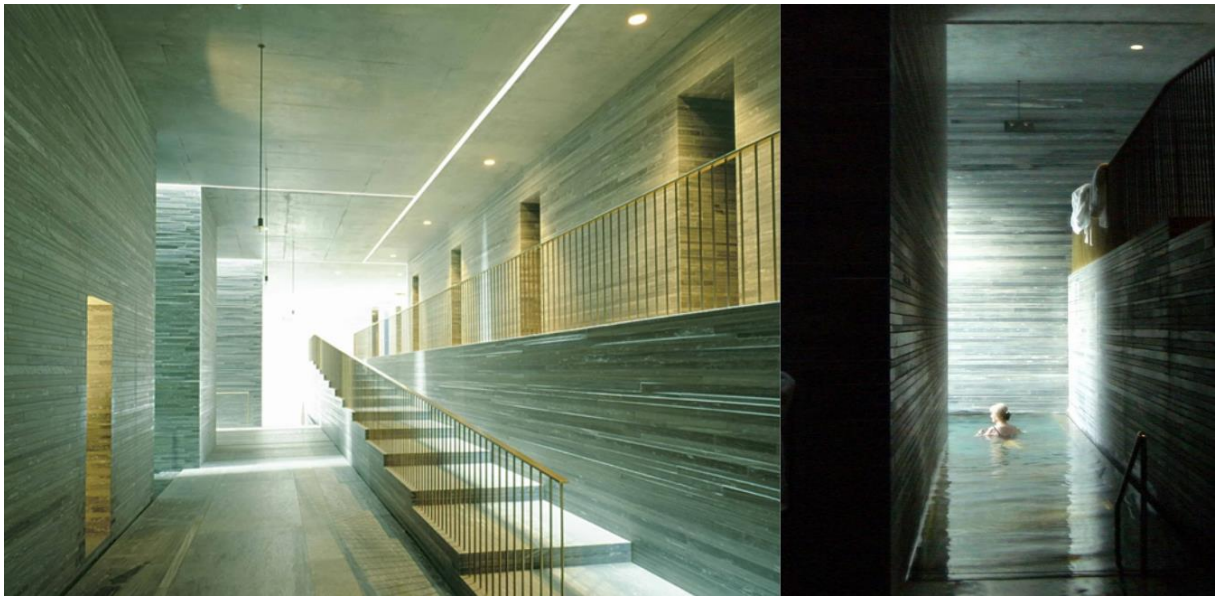
The definition of this research theme and discussion arises from the interest in creating new elements of teaching practice, bringing this phenomenological perspective to light. In other words, sometimes deconstructing the current classical teaching. According to the study by Stephenson et al. (2010) from the perspective of phenomenologist Edmund Husserl (1905/1966), perception should not be understood as passive reception but as active construction (Stephenson et al., 2010 apud Kastrup, 2013). According to Husserl (1966), phenomenology is a concept from philosophy that professes a return to the initial knowledge of being, constituted by the most primary sensations, such as tactile, olfactory, auditory, gustatory, and visual impressions. In architecture, some of these concepts can be used when the professional is interested in intensifying the sensory experience, such as the influence of light entry in spatial modeling (light and dark), interaction with translucent or opaque materials and

their reflectivity characteristics, or voids and solids in the building surfaces allowing more or less daylight penetration. In this sense, this perspective can be applied to lighting education to emphasize the importance of creating environments that not only meet technical requirements but also resonate emotionally with users.

In contrast to the dissociated teaching of light about architectural design, where the general objective is to teach lighting with a quantitative approach without perceiving the forms and sensations of light, **four theorists** present a general and/or specific approach to the poetics of light through a phenomenological lens. **Juhani Pallasmaa** advocates humanist architecture and his sensory and poetic approach to architectural design. Furthermore, Pallasmaa (1994) treats the built environment as integrated into our identity by stating that space becomes part of our own body and being, that is, our sensory perceptions. The author also argues that architecture, in its condition, is a relational art that accommodates human body measurements, invites action, embraces, shelters, and is provocative (Pallasmaa, 2013). Architectural space is a lived space, not merely a physical space, and lived spaces always transcend geometry and mensurability (Pallasmaa, 2011). In other words, the author addresses an approach beyond simple "seeing," pointing to the perception of the human being about the architectural work. Thus, in connection with lighting education, educators are invited to apply light as a complete element, stimulating sensory experience as a learning objective.

The choice to bring principles from **Peter Zumthor's** works as a reference for developing an integrative educational practice stems from Pallasmaa's (2011) argument in his book "The Eyes of the Skin: Architecture and the Senses," which states that in today's Architecture, the multiplicity of sensory experiences is intensified in the work of Glenn Murcutt, Steven Holl, and Peter Zumthor (Pallasmaa, 2011). The Swiss architect, who had various educational experiences discussing architectural thinking, demonstrates his multidisciplinary interest in evoking place, material, energy, presence, memories, images, density, atmosphere, permanence, and concentration as fundamental principles (Zumthor, 1998; Zumthor, 1997; Zumthor, 2006). The author approaches light with the question: "How will light react in the environment?" Additionally, Zumthor argues that "natural light, the light on things, is so moving to me that I feel it almost as a spiritual quality." He also mentions that light "gives a sense that there is something greater than everything" (Zumthor, 1997). An example is the Vals Thermal Baths in Graubunden (Figure 2) Switzerland, designed in 1996, where Zumthor worked with materiality, site location, images, surface density, atmosphere, and natural and artificial lighting.

Figure 2 – Vals Thermal Baths



Source: Shota Vashakmadze, 2012.

Gaston Bachelard, when discussing the poetics of space, argues that the domestic environment explores the phenomenological perspective, and space can be decomposed into types and experiences encountered (Bachelard, 1994). Corroborating this idea, Soto-Estrada et al. (2016) state that feelings of comfort, protection, and home are transmitted by genes and rooted in the primordial experiences of countless generations. In other words, how sensations are explored through architectural language can also vary concerning cultural expression and personal memories. "One will see if one has 'visions.' One will have visions if one educates oneself with daydreams before educating oneself with experiences if experiences come later as proof of one's daydreams" (Bachelard, 2016 apud Alberton, 2021). In the book "The Poetics of Space," Bachelard presents three arguments that can be related to integrated design practice with lighting education. The first is that the house is the first world of man (Bachelard, 2008). From then on, generating this feeling in students towards the environment can make them develop welcoming environments that promote users' well-being and mental health. The second argument is that "Habitable space is an imagined space" (Bachelard, 2008), which can be a principle that teaches students how lighting can be used to create different visual effects and atmospheres. They can learn how light evokes emotions and creates a sense of place. The third argument states: "The house is the first world of man, and, as such, is the world of dreams" (Bachelard, 2008). This can encourage students to appropriate these relationships and indicate how to use this information to create projects that promote well-being, safety, and aesthetics. Another author who corroborates Bachelard's theories is Howard Brandston, who, when discussing learning to see from perceptions, brings multidisciplinary teaching as essential.

Howard Brandston, a renowned lighting designer, emphasizes the importance of "learning to see" and highlights the need for a multidisciplinary approach to lighting education. Brandston argues that the perception of light and its impact on architectural space cannot be fully understood solely through a technical lens. In his words, "the true understanding of light and space requires an integration of knowledge from various disciplines, including art, science, and psychology" (Brandston, 2006). Throughout his career, Brandston completed numerous projects. Still, he considers the lighting design for the Statue of Liberty (Figure 3) as his most significant work, as mentioned in an interview with *Lume Arquitetura* (ed. 34/2008). This multidisciplinary view aligns with Bachelard's phenomenological approach, which values subjective experience and sensory perception as fundamental to understanding space. Brandston (2006) maintains that "light has the power to transform space, evoke emotions, and create a sense of place," aligning with Bachelard's idea that habitable space is also an imagined space. By integrating these perspectives into lighting education, students can learn not only to design with technical efficiency but also to create environments that resonate emotionally and psychologically with users.

Figure 3 – Statue of Liberty

Source: Matt Campbell, 2023.

In conclusion, while the classical approach focuses on technical precision and compliance with standards, the phenomenological approach values individual perception and sensory experience. However, these approaches do **not need to be mutually exclusive.** On the contrary, integrating both can provide a more comprehensive education.

2.2.1 How Does the Brain Learn?

When defining this question as the title of this section of the review, the intention was not to explain the biological foundation of neuron synapses but rather to establish the relationship between brain function and learning. This area of knowledge is currently known as neuropedagogy, which is a field within neuroscience and pedagogy that seeks to understand how the brain learns to adapt teaching techniques, plan strategies, and interventions in the cognitive, organic, emotional, and socio-interactive competencies of students. Before discussing how this can occur in adult undergraduate learning, it is important to note that, as a whole, the pattern of connections in a particular brain area can be described, but the microscopic variability of the brain in its finest neural branches is enormous, making each brain significantly unique (Edelman and Tononi, 2000).

Thus, this section is developed from the focus on what neuroscience[2] and neuroplasticity[3] say about the functioning of learning. The brain, as we know, is the most important part of our nervous system because it is through it that we become aware of the information that comes through the senses and process this information by comparing it with our experiences and expectations (Cosenza, 2009). Neuroscience is just beginning to unravel the mechanisms of sensation, attention, perception, emotion, thought, evaluation, and action, as well as the changes these mechanisms cause in the brain (Bear, Connors & Paradiso, 2020). In another study, Spitzer (2014) comments that neuroscience research clearly supports the general ideas of experimental psychology. However, research has shown that neural connections change with their use, a phenomenon now widely known as neuroplasticity.

Thus, it is possible to identify that knowledge acquisition, according to Kirschner (2002), consists of sensory, working, and long-term memories. Sensory memory is responsible for capturing information from the senses and lasts approximately two seconds. When the brain pays attention to this information, it is transported to working memory, where it will be processed (Falcade et al., 2020). Knowledge acquisition occurs when information processed in working memory is stored in long-term memory, which has unlimited space (Falcade et al., 2020; Kirschner, 2002).

Moreover, Spitzer (2013) argues that stored information (in the form of synaptic connections) is continuously used in processing neural information from input signals to predict what is most likely to happen next (to act, not just react). Thus, learning is the process through which things or events in the world are associated, allowing us to acquire new knowledge. We call memory the process by which we

[2] Neuroscience is the study of nerve cells and their interactions in the nervous system, investigating the biological processes underlying behavior and mental functions (Kandel, Schwartz & Jessell, 2012).
[3] Neuroplasticity is the brain's ability to reorganize itself by forming new neural connections throughout life, particularly in response to learning and experience (Doidge, 2007).

retain this knowledge over time (Mora, 2004). These processes are fundamental for humans, as they allow the transmission of knowledge and the creation of culture. Forms, colors, and movement are constructed in the neural networks of our brain based on the fundamental pre-program we inherit and the information we receive from the environment, enabling us to understand and process the surrounding information (Mora, 2004). According to Kastrup (2001), over the years, learning has been treated as a science, leading to the search for laws of learning. If the learning process is subject to scientific laws, its results are predictable (Kastrup, 2001). However, Kastrup (2004), in another study, states that from the perspective of invention, cognition is not limited to a functioning governed by invariant laws and principles occurring between a subject and a pre-existing object. Thus, another concept arises, that of invention, which, for thinkers, is linked to focus and attention (Kastrup, 2004; Cosenza, 2009; Spitzer, 2014).

It is understood that learning is the process by which things or events in the world are associated, and new knowledge is acquired, while memory is the process by which this knowledge is retained over time. Sensory memory is responsible for capturing sensory information, and working memory processes this information. In other words, creating integrated project situations stimulating the student's senses can promote knowledge consolidation. Specifically, light can aid in the consolidation of knowledge in the individual.

Attention is not a unitary phenomenon, and different mechanisms can regulate it. One way to classify attention is between reflexive attention, driven by peripheral stimuli, and voluntary attention, whose control mechanisms are central (Kastrup, 2004). According to Cosenza (2009), something is more likely to be considered significant and thus receive attention if it makes sense in the individual's context, is connected to what is already known, meets expectations, or is stimulating and pleasant. Additionally, cognitive psychology studies indicate that repetition, elaboration, and consolidation are important processes at this stage. From these processes, it is possible to discuss basic proposals and tools for integrating architectural design and light, which present results in the three stages of these processes.

Therefore, integrating this knowledge into lighting education in architecture can result in more effective pedagogical approaches. Architectural projects that use light not only as a functional element but also as a sensory and educational tool can facilitate information retention and consolidation. In this way, students can directly experience how light influences perception and memory, allowing for a practical and in-depth understanding of lighting concepts.

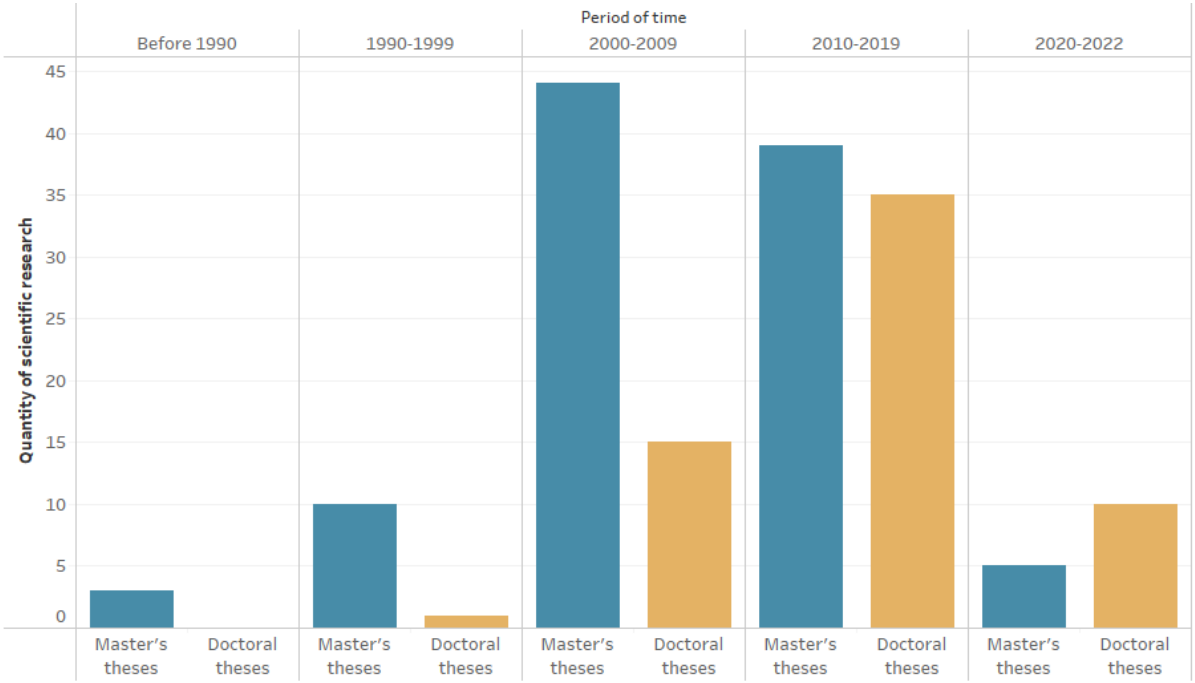
2.3 ARCHITECTURE TEACHING

2.3.1 Systematic Literature Review of Theses and Dissertations

According to Morosini and Fernandes (2014), the state of knowledge refers to the identification, recording, and categorization that leads to reflection and synthesis on the scientific production of a particular area within a specific time frame. Therefore, it was necessary to investigate through a literature review method to identify the knowledge and research produced **regarding teaching and learning practices in architecture** at the national level. This section contributes to the discussion on teaching by analyzing existing studies, thereby broadening the debate and reflecting on the importance of the topic. The relevance of this topic to the field of architecture is significant, as it allows for the merging of old and new practices, aiming to improve teaching practices. The literature review procedure used explicit and systematic methods for searching, critically appraising, and synthesizing selected information.

The database used was the CAPES Theses and Dissertations Catalog, with the keywords: "teaching of architecture and urbanism"; "teaching in architecture and urbanism"; "teaching in architecture and urbanism." Initially, 308 results were found, comprising 208 dissertations and 100 theses. Of these, only 101 dissertations and 61 theses were related to the researched topic of architecture education in various spheres, such as heritage, urbanism, and design. Most of these studies were produced between 2000 and 2019 (Figure 4), indicating a progression from master's to doctoral academic trajectories.

Figure 4 - Number of Dissertations and Theses by Decade



Source: Prepared by the author

Based on the study's intention and the implementation of transdisciplinarity concepts, as well as potential similar methodologies, it was deemed pertinent to analyze the selected works from simplified, quantitative, and qualitative perspectives. The approach employed in these theses and dissertations on architecture education was categorized by thematic axes. To aid in classification, an extensive survey was conducted across national higher education institutions (IES) regarding the categorization of thematic axes within the courses. From this, the following guiding axes were defined for this research:

1. Conception Axis: This includes all subjects related to design conception, whether architectural, urban, or landscape.

2. Representation Axis: This includes subjects related to the development of design representation skills, whether manual or digital.

3. Reflection Axis: This encompasses all subjects related to the history of art, architecture, urbanism, and landscape architecture, as well as all theory and criticism subjects.

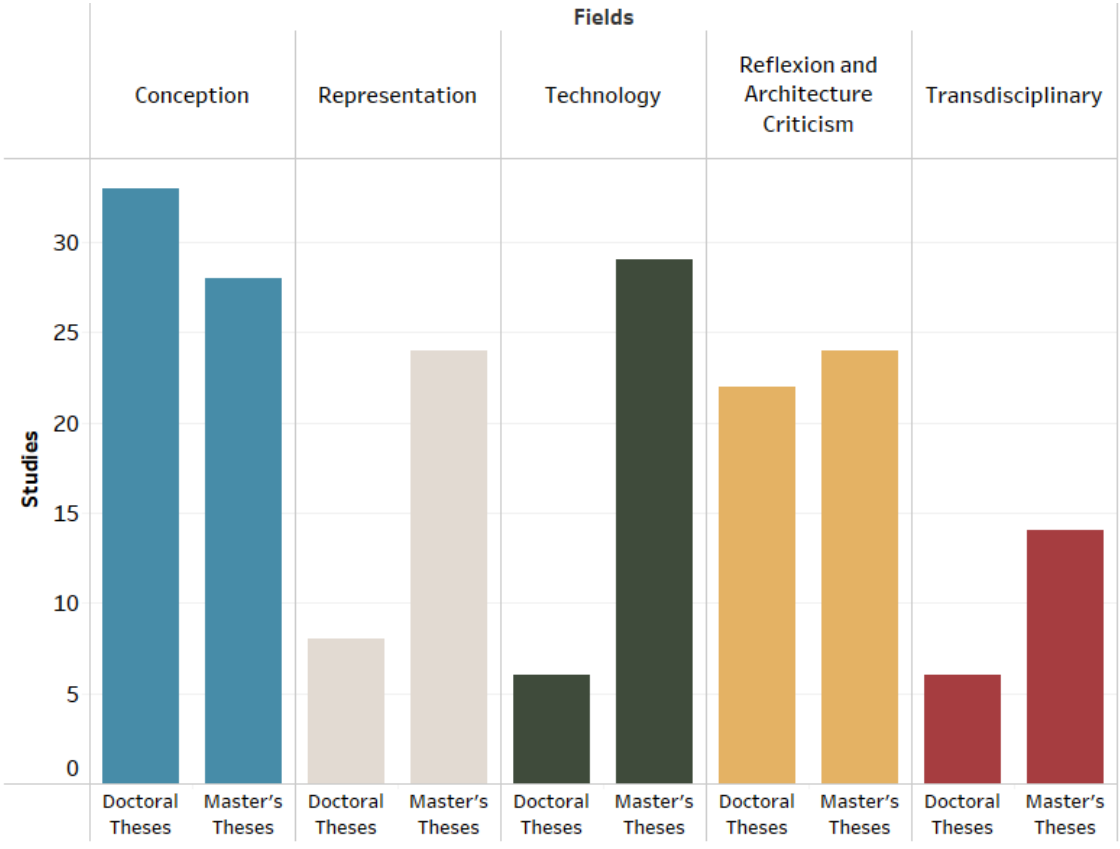
4. Technologies Axis: This consists of subjects related to materialization, construction and structural systems, comfort, and the environment.

Quantitative analyses of the 61 theses and 101 dissertations on architecture education were graphically represented based on the observation that scientific production is not directly related to the researcher who produces it but is particularly influenced by the geographical, social, and cultural

environment in which it is embedded. Regarding the regions of Brazil that stand out in producing research on architecture education through dissertations and theses, it is observable that, in terms of the number of IES, both dissertations and theses are primarily produced by the Federal University of Rio de Janeiro (UFRJ) and the University of São Paulo (USP). These are followed by the Federal University of Minas Gerais (UFMG) for dissertations, the Federal University of Rio Grande do Norte (UFRN), and the Federal University of Bahia (UFBA) in doctoral research.

In Figure 5, upon examining the research axes, it is noticeable that in the dissertations, the conception and technology axes stand out in the number of discussions related to teaching. Meanwhile, in the theses, the axes with the greatest quantity are those related to conception (1st) and reflection (2nd). Research that broadly addresses architecture education, discussing issues such as the fundamentals of pedagogical projects, the meaning of pedagogical knowledge in higher education, learning strategies, and rethinking architect training (Vital, 2019; Valente, 2014; Naruto, 2006), was classified as transdisciplinary, as they cross various axes in their discussions. In this analysis, some research addressed more than one theme, thus resulting in a greater total number of produced works.

Figure 5 - Number of Dissertations and Theses by Research Axes



Source: Prepared by the author

After the quantitative analysis, two main qualitative research axes were identified. The first axis encompasses studies that, in some way, address integrations, fundamentals of pedagogical projects, their significance in higher education, learning strategies, and the rethinking of architect education. The second axis focuses on studies that consider the project to be a fundamental element for possible relationships with other axes.

2.3.1.1 Integrated Teaching in Architecture

In the studies that generally discuss the integration between axes or broadly approach the course and its transdisciplinarity, there is a division into three sub-items: (1) knowledge and conditions of instructors; (2) curriculum analyses; (3) the construction and/or transformation of the teaching of architecture and urbanism over the years.

2.3.1.1.1 Knowledge and Conditions of Instructors

Initially, when investigating the knowledge and conditions of instructors, a recurring term was noted in Isoldi (1999), Lamberti (2008), and Alberton (2021), referring to the term "architect-professor." This term highlights the chronological order of their training and critically evaluates the teaching profession as a consequence rather than foundational training. Isoldi (1999), after conducting interviews with professors of Architecture and Urbanism, outlined a repository based on five types of knowledge: (1) knowledge from professional professors training institutions, (2) subject knowledge, (3) knowledge from experience gained through daily teaching practice, (4) knowledge specific to the profession of architecture, and (5) knowledge resulting from a close relationship with the field of education. Similarly, Lamberti (2008) pointed out that the role of the architect-professor requires direct contact with human beings, respecting all their particularities. Besides technical training, professionals need pedagogical knowledge to improve their interaction in the teaching-learning process.

Regarding the conditions of instructors, Costa (2008), Amorim (2015), and Alberton (2021) present essential knowledge for teaching architecture in their research. Costa (2008) discusses the knowledge and didactic practices of architect Sérgio Ferro in his teaching role, based on an understanding of his texts in the context of the political and cultural debate of the time. For Sérgio Ferro, the construction site, as a place of new social practices and renewed work, is the training ground. It is through the correct interpretation of reality and the political act of transforming it that the individual is formed (Costa, 2008). Amorim (2015) presents the teaching experience of architect John Hejduk (1929-2000) between 1964 and 1971, highlighting the union of theory and design practice and discussing the need for parallel and joint professional and teaching activities. Meanwhile, Alberton (2021) argues that design practice is central in the initial training of the architect-professor and, consequently, in design

teaching. Therefore, classroom and professional practice, although they have different objectives and subjects, are interconnected by this central and common design theme (Alberton, 2021).

Gonçalves (2019) addressed discussions about the training of architects and urban planners, understanding the current scenario of education and architectural production as fundamentally based on a mechanistic view. The research suggests that the training of this professional should keep pace with societal development, thus awakening an understanding of systemic vision that considers the broad and complex issues of contemporary cities. From this perspective, the importance of constructing an architecture and urbanism education based on a systemic vision is defined, focusing on seeing and understanding the whole and analyzing each agent and situation that forms it.

Corroborating this same idea of analyzing each agent and the situation that shapes it, Luz (2019) developed her research based on the inquiry that "knowing how to do architecture" does not necessarily mean "knowing how to teach architecture." As a result of interviews and engagement with academic demands, the researcher identified that faculty members often overcome challenges related to pedagogical practice by addressing them case by case. They reflect on their practice through trial and error, building and consolidating their knowledge through experience. Most experience this process individually, in isolation, and often feel vulnerable (Luz, 2019).

Finally, Arcipreste (2002) examined the pedagogical practice of architectural design, focusing on learning assessment processes. She conducted field research involving students and professors from design disciplines at three higher education institutions in Belo Horizonte. According to the author, the study's object was considered from two main theoretical frameworks, which complement each other in producing a diagnosis of the issue in the investigated context: the theoretical framework of teaching and assessment practices and the sociological framework—specifically, the sociology of culture and arts and the sociology of school assessment.

From this conceptual repertoire, the hypothesis of this thesis is revisited, highlighting the knowledge from professional professor training, didactic experience, knowledge specific to architectural education, human interaction, and didactic practices focused on integrated design exercise.

2.3.1.1.2 Curriculum Analysis

Mano (2012), before analyzing the curricula, addresses the axes he presented individually, identifying factors that either bring closer or distance from integrated practice. An example is the technology axis, which includes lighting, where the author points out that the isolation of technology subjects may be involved in a process of trivialization similar to what appears to be happening to the concept of

sustainability in some design studios. The absence of critical-theoretical reflection can turn potentially architectural content [design-oriented] into a mere imitation of techniques and ready-made solutions from [not always] notable references (Mano, 2012). This leads to a reproduction process contrary to the critique in design exercises. After the individualized approach, the author presents experiences in international IES and analyzes two specific curricula from UFRJ and Escola da Cidade, focusing on identifying their limitations and potentialities concerning curriculum integration.

Similarly, with this specific curriculum analysis perspective, Contier (2001) analyzed the organization of architecture courses in the São Paulo Metropolitan Region. Based on the questions "teaching for whom, by whom, what, and how," with "for whom" and "by whom" answered through student and faculty profiles, "what" referring to the curriculum, subjects, courses, and their organization, and "how" corresponding to the discussion of pedagogical practices and strategies. Santos (2001), in his research based on curriculum analysis, considered the Minimum Curriculum as the research object, which lasted from 1969 to 1994, demonstrating that, during this period, the perception of fragmentation in teaching conception and professional educating originated in the modernist ideology. According to him, the current characteristics of architecture and urbanism education primarily resulted from the search to build a comprehensive and innovative teaching and training concept, the object of collective reflection by students, professors, and professionals in previous decades.

In this curriculum analysis, two authors stood out for their analysis from different perspectives. Santos (2002) addressed the undergraduate curriculum in Architecture and Urbanism in Brazil from a socio-historical perspective, while Neto (2007) approached it from the viewpoint of traditional, humanistic, behaviorist, cognitive, and sociocultural education. Santos (2002) indicated that one of the biggest problems with education stems from the naturalization of a logic of fragmentation in how knowledge is handled. This is especially evident in the structuring of curricula: instead of path, process, and project, the curriculum has become a grid, mold, and standard, assuming a purely administrative bias. The formation of critical and autonomous subjects, the primary goal of education, finds in the curriculum, which, in the current organization of the Brazilian educational system, can be considered a hindrance (Santos, 2002). The author also defines that discussing a curriculum means also discussing the field of architecture, concluding that research presents itself as an alternative.

Neto (2007), from the perspective of various facets of education, treats it as a transformative agent of professional practice. The study considers that the teaching of architecture should not focus on a single approach but rather mix the positive aspects of each one for knowledge, highlighting that each individual has their own pace that must be respected for them to develop and produce more effectively

(Neto, 2007). He also points out that curricula should not be simply available on institution websites but could be presented to students by the professors of the courses themselves, showing the existing correlations. Finally, Braz (2016) investigates the curricula from a comparative perspective of two IES and two spheres of design focused on new digital technologies, the so-called Information and Communication Technologies (ICTs). The contributions of this research align with the review of teaching methodologies in the face of ICTs. For the teaching of Architecture and Urbanism Design, in particular, it raises demands for reviewing spaces or spatial arrangements and rethinking the dynamics of the educational space (Braz, 2016).

2.3.1.1.3 Construction and Transformation of the Practice of Architecture and Urbanism Over the Years

In relation to the construction and transformation of the Architecture course, the research can be subdivided into two main themes: one analyzing the general Brazilian reality (MINTO, 2009) and another focusing on discussions related to specific higher education institutions (HEIs) (PRONSATO, 2008; MONTEIRO, 2007; PINTADO, 2000). According to Minto (2009), his survey identified that the curricula of architecture schools have abandoned practical experimentation on construction sites, concentrating their activities exclusively on theoretical subjects and practical design activities. He highlights the importance of understanding the reality of construction sites beyond just the building process, emphasizing the significance of the various stakeholders involved, who often work in inappropriate, alienating environments and are easy targets for exploitation (MINTO, 2009).

Pronsato (2008), in her thesis, focuses on the formation of architects, centering the debate on the teaching of architecture and urbanism during the 1960s, 1970s, and 1980s, thus observing the transformations over the years. The specificity of this research included the teaching experience at the Faculty of Architecture of São José dos Campos, FAUs USP, and UnB as direct references in Brazil, along with Taller Total at FAU-UNC in Argentina. The author concludes that transformations over the years have defined architecture and urbanism as primarily social professions, and that teaching should be based on the analysis of society and its needs, within a democratic and participative management framework.

Monteiro (2007), focusing on the transformation of universities in the state of São Paulo, identifies how they are directly linked with the standards resulting from the characteristics of São Paulo's territory, relevant legislation, and actions of various agents, all associated with the logic of the higher education market. The results indicate an expansion of courses driven by market logic, associated with

the economic characteristics and potential of the territory, suggesting a need to expand affirmative actions that bring architects and urban planners closer to society (MONTEIRO, 2007).

Finally, Pintado (2000) analyzed the trajectory of architecture and urbanism education at the Federal University of Pelotas, through an examination of the course curriculum. At the institution studied, over the last 28 years (up to the date of the research), 17 curricula were implemented. The research observed that, while the curriculum is a key component organizing the various elements of higher education, curricular reform does not necessarily directly influence teaching or learning reforms. Thus, the scope of this thesis focuses on the integration between architecture and urbanism projects and lighting education, steering away from analyses and discussions focused on complete curricular reforms as a justification for improving teaching and student learning.

2.3.1.1.4 The Project and Its Integrative Potential

To observe the behavior of research addressing the project as an action with integrative potential in different areas of knowledge in architecture and urbanism, a subcategorization was created. These subcategories include their relationships with the axes of reflection, technology, and representation. Among the 28 dissertations, although focused on a specific axis, three categories were identified: (1) investigation based on the presentation of existing experiences; (2) investigation based on integration with another axis; (3) investigation based on innovation.

The dissertations that fall under the category of investigation based on the presentation of existing experiences reflect a significant effort to document, analyze, and understand already established pedagogical and methodological practices in architecture education. These studies offer a historical and critical perspective on various educational approaches, highlighting the impact of past experiences on the current and future development of architectural education. From teaching practices over several decades, providing a comprehensive view of evolutions and continuities in the field (Pinto, 1989; Trondoli, 2003). The exploration of specific institutional proposals and their impacts on student learning (Fontes, 2005; Trondoli, 2003; Batista, 2017). Or even with works that analyze the practices and curricula of various institutions, highlighting the diversity and similarities in educational approaches (Chiesa, 2006; Amaral, 2001; Vale, 2000; Castanho, 2018).

However, since the objective of this item is to understand discussions regarding integration, only item 2 was analyzed. In the dissertations, the studies developed from integration with other axes cover four approaches: (1) Integration with Information and Communication Technology; (2) Integration with Urban Planning; (3) Integration with Ergonomic Concepts; (4) Integration with Representation. This

highlights once again the gap in the intentions of discussing the integration of areas related to user comfort in design practices. Given that the central theme of this thesis focuses on lighting comfort and its relationships with design, even in other areas, the theses discussing integrations were reviewed, and favorable and unfavorable points identified by the authors were raised.

Amaral (2001) highlights the lack of a national cultural essence guiding the development of urban integrations, noting that approaches tend to focus excessively on anthropology, sociology, semiotics, and urban design without broader and culturally sensitive integration. This lack of cultural alignment may limit the effectiveness and relevance of urban projects in the local context. Complementing this view, Bersano (2003) observes that despite technological advancements with the use of CAD software and virtual reality, a proper balance between manual and digital methods in the representation and conception of architectural projects has yet to be achieved. The absence of this balance prevents technologies from fully realizing their transformative potential, highlighting the need for a more integrated approach that combines the best of both worlds: manual and digital.

This technological transition and integration become even more complex when analyzed from the perspective of practical difficulties, as pointed out by Martins (2013). In the transition from manual to digital drawing, the major obstacles include a lack of adequate infrastructure and users' low familiarity with software. This suggests the need for investments in both technology and technical training to facilitate this integration. Interdisciplinarity in architecture education also emerges as a crucial theme, according to Batista (2017). The author concludes that to effectuate interdisciplinarity in the Architectural Design course, it is necessary to restructure the discipline and reformulate the Course Pedagogical Project (PPC) and the teaching plans, besides the active involvement of professors and students. The integration of theory and practice is essential, and the lack of communication and articulation between different areas of knowledge can hinder the comprehensive education of students.

Finally, Boaventura (2017) explores integration through diagrammatic processes, promoting an effective articulation between place and project. However, the challenges include the difficulty students face with technical aspects like topography, as well as the lack of time in subjects to deepen both theory and practice. Additionally, the compartmentalization of the course and the specialization of professors limit the construction of broader and more integrated architectural knowledge.

Regarding the investigation of innovation in design conception, BIM (Building Information Modeling) emerges as the predominant practice. Two studies test application modalities in design studios and evaluate their potential and weaknesses. Within this application, it is important to highlight the identification of how it can improve students' understanding of construction processes and project

management (Delatorre, 2014). The proposals suggest a gradual approach to implementing BIM, starting with integration into basic subjects and advancing to more intensive use in final projects. They also discuss challenges such as the need for professor education and the adequacy of universities' technological infrastructures. However, they also point to resistance to change and a lack of adequate resources as significant barriers, highlighting the need for institutional policies to promote adopting and integrating this technology into curricula (Delatorre, 2014; Lima, 2018; Arantes, 2020). Others focus on BIM as a complementary methodology to design, where concepts like Virtual Studio emerge as an innovative platform that allows the simulation of natural project environments, facilitating student interaction and collaboration (Santos, 2017; Santos, 2001).

In the theses, among the 33 studies, four categories were identified: (1) Content Integration in Design Education; (2) Architect and Urban Planner Training as Designers; (3) Methodologies and Tools in Design Education; (4) History and Theory of Architecture in Design Education.

However, just as in the dissertations, only analyses related to integration will be presented, that is, item 1. Thus, Teixeira (2005) corroborates the hypothesis of this thesis, emphasizing the importance of a pedagogical structure that favors content integration, especially in mandatory design subjects. According to the author, this approach promotes a more cohesive practical application of the knowledge acquired, improving the understanding of architectural concepts and the efficiency in project development. However, the author also highlights difficulties in organizing theoretical and technical knowledge, often left to be integrated by the student, resulting in fragmented learning. Moreover, the limited time available in subjects to deepen theory and technical practice hinders the technical advancement of students' proposals and limits the construction of broader and more consistent architectural knowledge. Arcipreste (2012) reinforces the importance of student autonomy in the teaching-learning process and the central role of the advisor, as well as the relevance of continued research in design processes. The integration of diverse knowledge broadens the understanding of architectural phenomena and contributes to the formation of architects and urban planners with an interdisciplinary approach and high critical capacity. However, the author identifies challenges such as the persistence of meritocratic barriers, the lack of effective criticism of architectural productions and the architect's role, and the excessive compartmentalization of the course into theoretical, technical, and practical subjects, which hinder the construction of broader and integrated architectural knowledge.

Dornelles (2014) highlights universal design teaching strategies as a favorable point, as they contribute to academic reflection on the application of universal design in projects. The unfavorable points reported by the author include the underutilization of computational systems by students, resulting in

training that falls short of market needs. The effective integration of information technologies in design education still faces significant challenges, such as high implementation costs and the need for profound internal changes in institutions. Cavalcante (2014) observes that the studio practice, where disciplines converge, allows for a deeper application and better articulation of content, resulting in quality gains in students' final projects. However, the author also identifies challenges, such as the need for professors and students to be willing to work in teams and practice dialogue, as well as the overload of work and the difficulty of efficiently operationalizing integration in all periods of the course. Finally, Pessoa (2019) concludes that interdisciplinarity facilitates the exchange of knowledge between different areas, promoting mutual enrichment that positively reflects on the quality of students' final projects. The integrated approach is seen as essential for developing a more realistic and collaborative pedagogical practice, preparing students for professional market challenges. However, challenges such as the initial resistance of professors and students to breaking the traditional teaching model, the complexity of coordinating disciplines, and the constant need to adapt teaching methods to new technologies and the profile of students are pointed out as significant obstacles.

Thus, a summary table of the above-mentioned research was prepared, identifying the positive and negative points found in their research, regardless of the axes in which their integration was sought.

Table 2 - Summary Table of the Literature Review

Author, Year	Type of Research	Positive Aspects of Integration	Negative Aspects of Integration
Amaral, 2001	Master's Dissertation	Emphasizes the importance of national cultural essence in urban development.	Excessive focus on theoretical approaches.
Bersano, 2003		Optimization of project representation and presentation using technologies.	Imbalance between manual and digital methods, limitations in transforming the process.
Martins, 2013		Better preparation for professional practice.	Lack of infrastructure and familiarity with software complicate the transition.
Batista, 2017		Proved to be essential in practice.	Need for reformulation of PPC and teaching plans, insufficient communication and integration.
Boaventura, 2017		Promotes effective articulation between place and project.	Students' difficulties with topography, lack of time for theory and practice.
Teixeira, 2005	Doctoral Thesis	Pedagogical structure favors content integration in mandatory courses.	Difficulty in organizing theoretical and technical knowledge, fragmented learning.
Arcipreste, 2012		Importance of student autonomy and the central role of the advisor.	Meritocratic barriers, lack of effective criticism, and course compartmentalization.

Dornelles, 2014	Effective teaching strategies for universal design, positive student outcomes.	Underutilization of computational systems, education falls short of market needs.
Cavalcante, 2014	Studio practice allows for better content articulation and quality in final projects.	Need for teamwork, workload overload.
Pessoa, 2019	Interdisciplinarity facilitates knowledge exchange across different areas.	Initial resistance to change, complexity in coordinating disciplines.

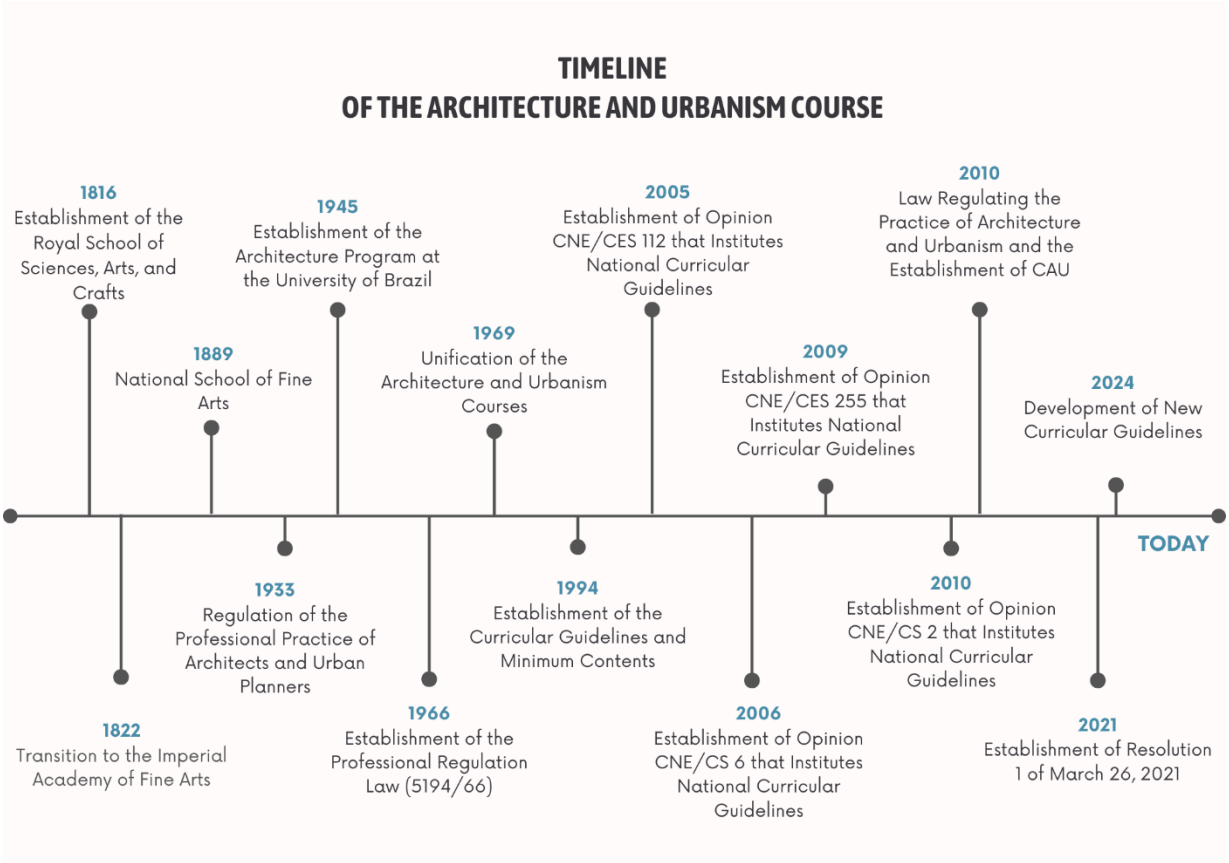
Source: Prepared by the author.

Thus, studies like those by Teixeira (2005) and Cavalcante (2014) suggest that the integration of content and studio practice can significantly enhance the articulation of knowledge acquired by students, promoting a more cohesive and practical understanding of architectural concepts. However, this integration faces significant barriers, such as resistance to change from professors and students, lack of adequate infrastructure, and workload overload. These challenges indicate the need for a review of teaching methodologies, not only concerning lighting but also other content and practices.

2.3.2 Historical Milestones and Legislation on Architecture and Urbanism Courses

To enable a critical discussion about lighting education within the context of Architecture and Urbanism courses, it was deemed important to understand the formal and informal transformations in academia, as well as its regulations. Therefore, it became necessary to outline a brief historical trajectory of the evolution of relevant legislation that has governed the present to discuss potential future improvements. Figure 6, presented below, was created by the author as a summary timeline based on materials published by the Brazilian National Archives, the Council of Architecture and Urbanism (CAU), the Brazilian Association of Architecture and Urbanism Education (ABEA), and federal legislation that was consulted directly on the official website of the Federal Government.

Figure 6 - Timeline of the Regulatory History of Architecture and Urbanism Courses in Brazil



Source: Prepared by the author.

As presented, in Brazil, the teachings of architecture began through the Royal School of Sciences, Arts, and Crafts, created by D. João VI, which, according to Gouvea (2018), also included courses in painting and sculpture. The first architecture course was divided into the following areas: history, construction, stereotomy, graphic representation, and composition. In 1822, the school changed its name to the Imperial Academy of Fine Arts, and in 1889, it became known as the National School of Fine Arts. In 1933, Decree No. 23,569 established the first regulation of the Professional Practice of Architects. Article 30 defined the roles of architects and engineer-architects, including the study, design, supervision, inspection, and construction of buildings and artistic, urbanistic, and landscape works. Additionally, their responsibilities encompassed three areas: legal architecture, expert evaluations, and arbitration related to these fields. Up to this historical milestone, themes such as environmental comfort, habitability, and technologies were not considered fundamental responsibilities of these professionals.

Following the School of Fine Arts separation, the Architecture and Urbanism undergraduate program became part of the University of Brazil, now the Federal University of Rio de Janeiro. Concurrently, there was an attempt to include Urbanism as part of the Architect's education. According to Cordeiro

(2015), an example of this was the proposed curriculum reform by Lúcio Costa, then director of the School of Fine Arts, which sought to include Urbanism and Landscape Architecture courses. In 1966, Law No. 5,194 established the second Regulation of the practice of Engineer, Architect, and Agronomist Engineer professions. This law outlined the following Professional Attributions in Article 7:

> Article 7: The activities and professional responsibilities of engineers, architects, and agronomists consist of:
> a) Holding positions, functions, and commissions in state, semi-state, autonomous, mixed-economy, and private entities;
> b) Planning or designing, in general, regions, zones, cities, works, structures, transportation, exploitation of natural resources, and the development of industrial and agricultural production;
> c) Studies, projects, analyses, evaluations, inspections, expert reports, technical opinions, and technical dissemination;
> d) Teaching, research, experimentation, and testing;
> e) Supervision of works and technical services;
> f) Management of works and technical services;
> g) Execution of works and technical services;
> h) Specialized technical production, whether industrial or agricultural.
> Sole Paragraph: Engineers, architects, and agronomists may engage in any other activity that, by its nature, falls within the scope of their professions. (Legislative Chamber)

In 1969, the Architecture and Urbanism courses were unified, and starting in 1994, the Commission of Architecture Teaching Experts, linked to the Higher Education Secretariat of the Ministry of Education, created a document titled "Profiles of the Area and Quality Standards"—which will be discussed in more detail in the next section. This document presented the themes of environmental comfort for the first time, separately highlighting the terms "acoustic, thermal, and luminous." Additionally, in the same year, Curriculum Guidelines and minimum content were established to propose a basic standard across different universities in the country. After 11 years, in 2005, Opinion CNE/CES 112 was published, instituting new National Curriculum Guidelines to be observed and adhered to, both for the creation of new courses and for the evaluation criteria of existing ones. In the following two years, Opinions (CNE/CS 6, CNE/CES 255, CNE/CS 2) were developed, instituting new National Curriculum Guidelines. At the end of 2010, the Regulation Law for the Professional Practice of Architects and Urbanists (Law No. 12,378, of December 31, 2010) was also updated, along with the establishment of the Council of Architecture and Urbanism (CAU/BR). This law determined the following in Article 2:

> Article 2: The activities and responsibilities of architects and urbanists consist of:
> I - supervision, coordination, management, and technical guidance;
> II - data collection, study, planning, design, and specification;
> III - technical and environmental feasibility studies;
> IV - technical assistance, advisory services, and consultancy;
> V - direction of works and technical services;
> VI - inspection, expert analysis, evaluation, monitoring, technical reports, technical opinions, audits, and arbitration;
> VII - holding technical positions and functions;
> VIII - training, teaching, research, and university extension;

> IX - development, analysis, experimentation, testing, standardization, measurement, and quality control;
> X - budgeting;
> XI - production and dissemination of specialized technical knowledge; and
> XII - execution, supervision, and management of works, installations, and technical services.
> Sole Paragraph: The activities referred to in this article apply to the following fields within the sector:
> I - Architecture and Urbanism, including the conception and execution of projects;
> II - Interior Architecture, including the conception and execution of interior environment projects;
> III - Landscape Architecture, including the conception and execution of projects for external, free, and open spaces, whether private or public, such as parks and plazas, considered in isolation or as systems, within various scales, including territorial;
> IV - Historical, Cultural, and Artistic Heritage, including architectural, urbanistic, landscape monuments, restoration, project practices, and technological solutions for the reuse, rehabilitation, reconstruction, preservation, conservation, restoration, and valorization of buildings, complexes, and cities;
> V - Urban and Regional Planning, including physical-territorial planning, urban, metropolitan, and regional space intervention plans based on infrastructure systems, basic and environmental sanitation, road systems, signaling, urban and rural traffic and transit, accessibility, territorial and environmental management, land subdivision, land division, merging, road layout, urban planning, master plans, city layouts, urban design, road systems, urban and rural traffic and transit, urban and regional inventory, human settlements, and requalification in urban and rural areas;
> VI - Topography, including the preparation and interpretation of cadastral topographic surveys for architecture, urbanism, and landscape projects; photointerpretation, reading, interpretation, and analysis of topographic data and information; and remote sensing;
> VII - Technology and resistance of materials, construction elements, and products, pathologies, and recoveries;
> VIII - Construction and structural systems, including structures, structural development, and technological application of structures;
> IX - Installations and equipment related to architecture and urbanism;
> **X - Environmental Comfort, including techniques related to establishing climatic, acoustic, luminous, and ergonomic conditions for the conception, organization, and construction of spaces;**
> XI - Environment, including Environmental Impact Studies and Assessments, Environmental Licensing, Rational Use of Available Resources, and Sustainable Development. (Legislative Chamber. Emphasis added)

In 2021, by amending Article 6, Item 1 of Resolution CNE/CED 2/2010, Resolution No. 1 of March 26 divided the undergraduate course in Architecture and Urbanism into two cores and a Course Work: the Core of Foundational Knowledge and the Core of Professional Knowledge. According to the document, the area of environmental comfort is included alongside architecture and urbanism projects within the Core of Professional Knowledge.

Thus, it was possible to identify that the development of architecture and urbanism courses in Brazil was influenced by the Schools of Fine Arts, which categorized the teaching. Their adaptation has been added over time due to demands, even though the consideration of the quality of spaces has always existed, albeit not always clearly and objectively. As a result, the development of the professional

attributions of Architects and Urbanists directly affects the design of training courses. Observing qualifications and societal needs carries challenges, whether in organizing disciplines, managing the workload, or shaping professional education to update teaching methodologies to contemporary practice and best prepare students to excel in various fields of work.

Therefore, this section is structured into two subtopics. The first addresses the regulatory guidelines for professor training with a didactic pedagogical focus. The second discusses the formation of Architecture and Urbanism courses and programs in Brazil, presenting opinions and resolutions, with a focus on analyzing the document "Profiles of the Area and Quality Standards," developed by the Commission of Experts in Architecture and Urbanism Education.

2.3.1.2 Regulatory Guidelines

To discuss about the teaching of architecture and urbanism, it is essential to consider the categories involved in the subject, such as faculty and students. Regarding the faculty, it is important to start with the Basic Guidelines Law (LDB) 9394/96. Beginning with Article 66, it states the following:

> Art. 66: Preparation for teaching in higher education shall be **conducted at the graduate level,** primarily in master's and doctoral programs. Sole Paragraph. A recognized expertise, acknowledged by a university offering a doctoral program in a related field, may substitute for the requirement of an **academic degree**." (Legislative Chamber. Emphasis added)

In other words, to be a professor in an undergraduate Architecture and Urbanism program, except in cases of recognized expertise, the law stipulates the completion of undergraduate (bachelor's) and graduate (*stricto sensu*) education. This implies a concept of training developed over experience rather than the necessity of training specifically focused on teaching. Furthermore, according to Article 13 of the LDB, faculty members are responsible for participating in the development of the educational institution's pedagogical proposal, preparing and following the work plan according to the institution's pedagogical proposal, and monitoring student learning. According to Veiga (2014), this lack of pedagogical training results in a professor-centered instructional practice. The author also argues that it is crucial for university faculty to understand the methods of interpreting reality and the object of scientific fields to effectively engage in teaching practice. This highlights a pedagogical demand for the Architect-Professor [4]professional.

In the realm of teaching practice, Damis (2010) notes that teaching occurs beyond a fixed time frame; it is characterized by the social actors involved in the process. As Freire (1973) asserts, no human action can be understood outside the historical context of its social and cultural relationships and structural

[4] The term *Arquiteto-Professor*, rather than *Professor-Arquiteto*, is derived from Alberton's thesis (2021), where the designation of professors in Architecture and Urbanism courses is defined according to the chronological order of their training and practice.

determinations. Thus, human action is always interaction, communication, and transformation. Consequently, the didactic organization should be viewed as a branch of educational science where methodology, whether active or not, serves as a tool for operationalizing the system that constitutes training (Veiga, 2014). Deleuze (1988) remarks that we learn nothing from those who tell us: "Do as I do." Our only teachers are those who say: "Do with me," and who, instead of proposing gestures to be reproduced, know how to issue signs to be developed in the heterogeneous. He further asserts that the teaching-learning relationship depends on a master who does not shy away from their role as a learner, which is a matter of cognitive politics[5].

Regarding the characteristics of academic organization, there are university and non-university institutions in the country, including University Centers, Integrated Faculties, Federal Institutes, and Isolated Faculties. This research will focus only on universities, as they are based on the pillars of teaching, research, and extension. In this context, according to the LDB, universities must demonstrate intellectual production and have at least one-third of their faculty with master's and doctoral degrees and one-third of their faculty in full-time positions.

Regarding students, it is always important to note the constant transformations in society, which directly influence the different cohorts each new academic year. Understanding the dynamics of new digital eras and technological advancements requires educators to have sensitivity and an open mind toward future developments. In this context of digitalization, Hinrichs (2004) emphasized that all the computers in the world won't make a difference without enthusiastic students. But how can they be motivated? This question sparked the interest in developing the chapter on "student engagement" and related topics, such as "How the Brain Learns" (2.2). While there are temporal variables, there are also scientific methods that aid in constructing learning. After all, according to Rozestraten (2007), in the early stages of architecture's development, knowledge was built through the confrontation of ideas and dialogue. Thus, why not consider transdisciplinarity as an epistemological issue and not just a methodological one? (Malard, 2006; Alberton, 2021). Methodologically, transdisciplinarity involves using techniques from various disciplines to solve complex problems. Epistemologically, it means rethinking the nature of knowledge, acknowledging the interconnection of disciplines, and promoting a comprehensive view that integrates different perspectives.

2.3.1.3 Architecture and Urbanism Course and the General Curriculum Guidelines

The Architecture course is currently based on the prevailing Opinion of Resolution No. 1 of March 26, 2021, which establishes new National Curriculum Guidelines. In addition to the aforementioned

[5] *Cognitive politics* refers to the practices, policies, and norms that influence and shape the production, dissemination, and use of knowledge in society (Innerarity, 2012).

Resolutions, the training is guided by the National Education Plan 2014-2024, Law No. 13,005 of June 25, 2014, and the MEC's Profiles of the Area and Quality Standards. These documents stipulate that the Architect and Urbanist should acquire the following competencies during their undergraduate studies:

1. **A solid generalist education;**
2. The ability to understand and **translate the needs of individuals,** social groups, and the community concerning the conception, organization, and constitution of interior and exterior spaces, encompassing urbanism, building, and landscaping;
3. The conservation and valorization of built heritage;
4. The protection of the balance of the natural environment and the rational use of available resources.

The above items highlight a curriculum focused on developing competencies and skills, moving from a general to a specific analysis. However, it is necessary to discuss the relationship between the first point and the others. While graduates should have a generalist education, they must also be capable of producing highly specific elements, such as translating individual needs through building design. Considering Le Corbusier's (1923) principle that "architecture is the learned game, correct and magnificent, of forms assembled in the light," it is impossible to separate general aspects from specific ones in the architectural education process.

According to the document titled “Profiles of the Area and Quality Standards,” prepared by the Commission of Experts in Architecture and Urbanism Education, linked to the Higher Education Secretariat of the Ministry of Education, the area profiles and quality standards are established, among which are the requirements for the opening and operation of courses, general curriculum guidelines (minimum content) as per Ordinance 1770/94, verification procedures, and the composition of the commission of experts. The document indicates that an evaluation process was conducted in the area of education, structured around the recognition of the area, self-assessment, and internal and external evaluation of the courses and graduates.

The document also presents a brief history, explaining that the drafting process began in 1990 and consisted of an assessment (state of the art) of the field based on the Inventory of Architecture and Urbanism Courses conducted by the Brazilian Association of Architecture Education - ABEA. In parallel with the drafting process, with a focus on lighting, the Technical Report “Lighting Educationting” by the CIE - International Commission on Illumination (CIE, 1992) emerged. This document, covering the years 1983 to 1989, concluded that lighting education, while addressing normative, compositional, and

functional aspects, still did not provide sufficient knowledge to architecture and engineering professionals.

The stages of this process also contributed to defining the new curriculum guidelines present in Resolutions from 1994 to 2021, where content, guidelines, and essential and thus required conditions for all architecture and urbanism courses are stated in a manner that preserves the characteristics of the profession, the legal requirements of professional regulation, and the quality standards necessary for the education and professional practice of architects and urbanists. In this 1994 period, the Brazilian commission that created the "profile of standards" identified that one of the fundamental problems in the educational framework was the existing separation between the teaching of design and the art of building.

Regarding laboratories, the document mandates the following four: computer lab, environmental comfort lab, construction technology lab, and photography, video, and audiovisual lab. The environmental comfort lab, the subject of this research, further specifies: “it should enable the use of modern analysis methods and familiarization with equipment that facilitates project orientation, considering environmental variables and their impact on buildings and cities, and the associated physical processes, to ensure the necessary and expected performance from the perspective of user satisfaction and energy efficiency” (MEC, 1994).

According to Article 2 of the General Curriculum Guidelines - Ordinance (MEC, 1994), item 6 addresses environmental comfort as the integration of the study of thermal, acoustic, lighting, energy conditions, and the associated physical phenomena as one of the determinants of the form and organization of space. In the section on the information to be provided by the IES for the opening and operation of courses, under the item "Environmental Comfort Laboratory," the objectives are:

> Develop the study of environmental control techniques through experiments, studies, and training involving temperature, ventilation, solar exposure, lighting, and acoustics, which can affect the natural, urban, and built environment. Provide faculty and students of Architecture and Urbanism with access to information and guidance that allows them to experiment with and even invent simple and necessary instruments for the proper environmental management of buildings. Develop ongoing evaluation to establish the didactic-pedagogical foundations and specialized tools in the area of Comfort in the Built Environment. (Legislative Chamber)

This raises the question of "how to establish and measure regulations that encourage not only technical approaches but also those with a non-functional perspective on lighting?" It is worth noting that while the 1994 MEC Ordinance 1770 required architecture courses to "have" environmental comfort laboratories, the 2021 document states that these laboratories "may" be implemented. This change represents a clearly radical shift that compromises the historical effort to improve the training of Brazilian architects.

However, the new guideline—in the process of publication—for Architecture and Urbanism courses in Brazil presents a significant advancement by aligning education with contemporary demands, replacing concerns from the previous regulation. Within the topics covered, points related to the theme of this thesis were selected. Article 16 states:

> **Art. 16.** The contents of Design for: Architecture, Interior Architecture, Urbanism, and Landscape Architecture encompass the organized set of scientific, empirical, and intuitive knowledge related to built space. This includes the stages and design processes of developing needs programs, conception, expression and representation, studies, definition of processes and construction techniques, detailing, and executive solutions for works in Architecture, Interior Architecture, Urbanism, and Landscape Architecture. (Legislative Chamber)

Thus, it can be observed that the article provides a comprehensive foundation by integrating scientific, empirical, and intuitive knowledge. Although this approach is broad, the regulation could be more specific regarding the integration of lighting in the design process. Considering that lighting is essential for the quality of the built environment, it should be highlighted as a fundamental competency, encompassing all stages from conception to execution. The lack of specific detailing on the approach to lighting may result in a superficial treatment of this crucial subject.

> **Art. 22.** The contents of Environmental Comfort and built space performance encompass the organized set of scientific, empirical, and intuitive knowledge, as well as laboratory experiments related to habitability and human comfort in environments; studies, conceptions, and proposals to ensure conditions of habitability and comfort, and the luminous, thermal, and acoustic efficiency of buildings and public spaces, respecting local environmental characteristics; the pursuit of technologies and alternatives for reducing water, energy, and natural resource consumption in addressing the climate emergency. (Legislative Chamber)

Article 22 addresses environmental comfort and the performance of built spaces, highlighting the importance of luminous, thermal, and acoustic efficiency for human comfort. Recognizing these elements as essential is a significant advancement, and the emphasis on seeking technologies that reduce the consumption of natural resources is crucial for sustainability and addressing the climate emergency. However, it would be beneficial to include more detailed guidelines on the practical implementation of this knowledge in curricula, ensuring that students acquire up-to-date and applicable skills in the field of lighting.

Regarding the curriculum organization, learning, and pedagogical aspects of the undergraduate Architecture and Urbanism course, paragraphs 1 and 2 of Section III emphasize the mandatory nature of laboratory activities and the integration of theory, practice, and application context. These are fundamental for developing comprehensive competencies and countering the previous directive. The

requirement for laboratory activities ensures that students have the opportunity to experiment with and test lighting solutions in controlled environments, which is essential for understanding the nuances of luminous performance. Promoting curricular extension and research is also crucial, as it encourages the application of theoretical knowledge in real-world contexts, preparing students for professional challenges.

Concerning the "profile and competencies and skills of graduates," the new guidelines in item XI of Section I highlight the importance of understanding bioclimatic variables and the demands of habitability and human comfort, as well as mastering techniques for thermal, acoustic, luminous, and energy efficiency. This guideline is crucial as it places lighting within a context of sustainability and well-being.

2.4 LIGHTING EDUCATION

2.4.1 Lighting Education in the Architecture Courses

As explained in the methodology, this section consists of reviewing studies on lighting education in two stages. The first stage involves a Systematic Literature Review based on the CAPES database of theses and dissertations, and the second involves national and international articles (item 3.4.2). The keyword "lighting education" did not yield any results specific to architecture-related courses on the platform. However, within the results for "architecture education," one dissertation (Dittz, 2004), one doctoral thesis (Matos, 2023), and one post-doctoral thesis (Scarazzato, 2018) were found. This finding complements and corroborates the gap in Brazilian research focused on architect training, serving as an invitation to discuss how lighting education has been conducted in Architecture and Urbanism courses and its reflections on professional practice.

In her dissertation titled "New Information and Communication Technologies in the Teaching-Learning of Lighting Comfort in Architecture and Urbanism," Dittz (2004) aims to understand and encourage new technologies in teaching-learning. The study initially conceptualizes distance learning, along with its advantages and disadvantages, following the emergence of E-learning[6] technologies and teaching-

[6] According to Govindasamy (2002) e-learning is defined as electronic learning that includes instruction through electronic means such as the Internet, audio/video tapes, interactive television, and other electronic media. The same author notes that the pedagogical principles applicable to traditional classroom methods can also be used in E-learning. However, these principles need to be expanded to adapt to the rapid technological changes.

learning environments, such as WebCT[7], TelEduc[8], and AulaNet[9]. It then explores new technologies like Hypertext[10], Multimedia[11], Hypermedia[12], Image, Animation, Simulation, Virtual Reality, and Human-Computer Interaction[13]. For her exploratory research using a convenience sample, a field study was conducted to collect data, involving interviews with visual professors. The objective was to profile the professionals and observe their familiarity with New Information and Communication Technologies (NICTs): Internet usage, computer knowledge, experience with NICTs, and Web-based Learning Environments. The study also sought to identify the peculiarities of the teaching-learning process of Visual Comfort, including pedagogical aspects, predominant methodology, critical points in approaching certain topics, and evaluation methods. Additionally, it explored the application of NICTs in supporting both in-person and distance learning, specifically in the context of Visual Comfort, and opinions on the use of these resources in teaching this area (Dittz, 2004). The study concluded that, due to structural and technical issues, there were still few initiatives at the time to use NICTs and Virtual Learning Environments for didactic purposes in this field (Dittz, 2004).

The thesis "Daylight in the Architecture Design Process: Development of a Virtual Support Tool" proposed a virtual tool to support architectural projects from the initial phases. The tool, tested in architecture courses at Unicamp, proved effective in student training, enhancing the understanding of daylight concepts and facilitating the integration of these concepts into the design process. It was useful both for quick consultations by students and as a source of content for faculty, applicable in exercises and project analyses. However, the tool presented some drawbacks, such as the need for prior knowledge about lighting, which may limit its use by beginners, and a heavy reliance on the desktop version. It was found that students have a limited understanding of the phases of the design process (Matos, 2023). A possible solution, as concluded by the author, would be to conduct an

[7] According to Dittz (2004), WebCT is a virtual environment developed at the University of British Columbia in Canada. Its objective is to facilitate the creation of distance learning courses.

[8] According to Dittz (2004), TelEduc is a virtual learning environment developed by NIED – Núcleo de Informática Aplicada à Educação at UNICAMP, with the aim of facilitating collaborative work.

[9] According to Dittz (2004), AulaNet was developed by LES – Software Engineering Laboratory, at the Department of Informatics of PUCRJ, with the aim of being an environment for the administration, creation, maintenance, and support of distance learning courses. Utilizing technological resources available on the Internet, it emphasizes cooperation among learners and between learners and instructors.

[10] According to Dittz (2004), hypertext differs from regular text in that, in addition to relying on a technological base (i.e., a computer), it allows for quick interaction between the main text and other supplementary texts through nodes. These nodes not only connect different texts but also link to other resources, such as images and animations. This connection means that the text no longer necessarily follows a linear structure, allowing the user to navigate the content in various ways.

[11] Multimedia is defined as "any combination of texts, graphics, sounds, animations, and videos mediated through a computer or another electronic medium" (Assis et al. 2002).

[12] According to Dittz (2004), some authors, such as Cardoso (1999), Assis (2002), Chermann (1998), and Souza (1998), define a hypermedia system as one that manages a set of information belonging to different types of media (text, sound, image, and others) and allows this information to be retrieved in a non-linear manner through various available access paths.

[13] According to Dittz (2004), the term human-machine refers to the means, graphical formatting, and ergonomics through which the interaction between the user and the content occurs. This content may or may not include hypertext, multimedia, hypermedia, images, animations, simulations, or even virtual reality.

explanatory class on the subject before applying the evaluation questionnaire or to establish a connection between the phases of the design process and the phases of the developed exercise.

Lastly, Scarazzato (2018), in his postdoctoral thesis titled "Questions of Light in Architect's Education," advocates the hypothesis that the studio should be the locus par excellence for the practice of lighting education. The author provides a brief history and theoretical concerns about the enjoyment of lighting as a craft, within the craft, and in other fields of knowledge. In his didactic proposal, based on "designing with light," he addresses sensitization through learning to see and exercises in observational drawing, photography, and the reading of key texts where light issues are presented as inseparable from design thinking and architectural space. Technical aspects, such as quantitative analysis and computational resources, are addressed to support the development of the necessary competencies without allowing the quantitative and functional approach to overshadow the perception of light as a shaper of architectural space (Scarazzato, 2018). The proposed exercises include the observation exercise, through observational drawing, followed by a design exercise generating an internal or external view with significant contrasts using natural and artificial lighting. The research also mentions exercises with scaled models (Figure 7) with an internal observation point and the use of augmented reality.

Figure 7 - Exercise with Scaled Models

Source: Scarazzato, 2018.

Thus, the importance of integrating lighting education with the design studio is emphasized. It is there that the practices of freehand drawing, photography, and the creation of scaled physical models can be experimented with—fundamental resources for exercising observation skills and sensitization to

light (Scarazzato, 2018). Based on these studies, a summary table (Table 3) was created with the authors' critical positions on various teaching experiences, along with the advantages and disadvantages found in their applications.

Table 3 - Summary Table of the Research

Author and Year	Title	Objectives of the Work	Intention/Theory	Advantages and Disadvantages
Dittz (2004)	New Information and Communication Technologies in the Teaching-Learning of Visual Comfort in Architecture and Urbanism	Understand and encourage the use of new technologies in teaching visual comfort, identifying the familiarity of professionals with NICTs and their applications in both in-person and distance education.	(1) Use of E-learning and teaching-learning environments like WebCT, TelEduc, and AulaNet; (2) Use of new technologies like Hypertext, Multimedia, Hypermedia, Virtual Reality	**Advantages:** (1) Introduction of new technologies to facilitate teaching; **Disadvantages:** (1) Limited knowledge among professors about the technologies; (2) Few initiatives due to structural and technical issues.
Matos (2023)	Daylight in the Architectural Design Process: Development of a Virtual tool to support the Project	Proposal of a virtual tool to assist in the inclusion of daylight considerations in the early stages of architectural design.	(1) Integration of the tool into design courses; (2) Use of the tool in both design exercises and analysis of existing projects.	**Advantages:** (1) Improved understanding of daylight concepts; (2) Facilitates the integration of lighting concepts into design. **Disadvantages:** (1) Requires prior knowledge of lighting.
Scarazzato (2018)	Questions of Light in Architect's Education	Didactic proposal that integrates sensitization to light with design education, using practical and technical exercises to develop necessary competencies without overshadowing the qualitative perception of lighting.	(1) Studio as the main locus for the practice of lighting education; (2) Sensitization exercises like observational drawing, photography, and reading of key texts.	**Advantages:** (1) Integration of lighting education with design practices; (2) Use of physical models and augmented reality for experimentation. **Disadvantages:** (1) Need to balance technical and perceptual aspects of light.

Source: Prepared by author.

Thus, this thesis supports Dittz's (2004) emphasis on the importance of incorporating new technologies into the teaching-learning process, considering that tools like virtual reality and interactive media can enhance the understanding of concepts related to visual comfort. However, this thesis disagrees with the notion that the low familiarity of professors with these technologies is an insurmountable obstacle.

Instead, it proposes professor training as a solution to maximize the use of these tools. Additionally, Mizoguchi (2016), in his work "Formação do Arquiteto," suggests that students should seek guidance from the professor in situations of difficulty. However, this approach may inadvertently exempt professors from the responsibility of exploring innovative pedagogical alternatives in studios. Therefore, the central role of professors in promoting and updating new methodologies and technologies in the educational environment is highlighted. Matos's (2023) study exemplifies that, despite the limitations arising from the need for prior knowledge, the creation of a tool to improve the understanding of daylight can facilitate the integration of these concepts into architectural design.

2.4.2 Systematic Literature Review at National and International Levels

In the second phase, a systematic literature review of national and international scientific articles was conducted by the author, advisor, and other researchers. This research was published and is included in its entirety in Annex A. Articles from journals and conference proceedings available in the Scopus, Web of Science, SciELO, and CAPES Periodicals databases were analyzed. The investigation focused on identifying common theoretical categories that reflect the themes addressed in the articles, facilitating comparative analysis of different approaches and educational contexts.

For the theoretical foundation of this thesis, points directly related to the subject matter and consistent with the chapters of this research will be highlighted. Expanding on the discussion of the SLR presented in the already published article, new categories of analysis are presented, namely: (1) analysis of lighting education, (2) analysis of graduates and faculty, and (3) analysis of students.

Regarding the **analysis of lighting education** (Sousa et al., 2023) in the international context, four of the reviewed articles are "opinion pieces" or "editorials" expressing views based on experiences in the lighting field. These articles highlight the importance of robust technical education that goes beyond performance and visual comfort, addressing lighting as a significant "message" for the user (Boyce and Mcibse, 2006). DiLaura (2007) emphasizes the need for essential technical and practical education due to contemporary dependence on lighting technology. Bech-Larsen, Linnebjerg, and Mullins (2018) map the necessary competencies for training aligned with the demands of the productive sector, while Lam (2021) emphasizes understanding the relationship between light and human health, proposing the incorporation of digital thinking and research in lighting design, integrating post-occupancy studies. In the Brazilian context, out of the twelve selected articles, four discuss the analysis of lighting education. Gonçalves and Duarte (2006) discuss the integration of lighting with environmental comfort and sustainability, highlighting the importance of applying this knowledge in the design process. Mülfarth (2018) reinforces this view, emphasizing the need to address lighting alongside other design variables.

Bogo (2002) suggests improvements in environmental comfort courses, including student experimentation and questioning. Faria (2014) focuses on the impact of computational tools on daylighting education, concluding that computer simulations facilitate students' understanding of the relationship between natural light and the built environment.

The analysis of the articles (Sousa et al., 2023) revealed two main approaches**: improvements in education through content exploration and improvements in the teaching process.** Boyce and Mcibse (2006) advocate for the integration of natural light in lighting projects, while DiLaura (2007) highlights the importance of technical education. Regarding the teaching process, Phillips (1956) criticizes the lack of connection between lighting projects and architectural works, suggesting joint activities between engineering and architecture faculties. Navvab (2014) highlights the importance of computer simulations as evaluation tools in lighting education and design. Mansfield (2017) identifies three crucial points in lighting education: learning through reading, collaborative courses, and online content that allows for topic interaction, as well as validating learning and promoting the production of technical reports and feasibility studies.

Regarding the analysis of architecture graduates and the university, the systematic review by Sousa et al. (2023) found that Bogo (2002) reflects on the challenges faced by Professors in environmental comfort courses. He proposes improvements in teaching, highlighting the importance of experimentation and encouraging students' inquiries. Bogo suggests that education should go beyond normative pragmatism, encouraging students to explore concrete situations and develop a deep understanding of lighting phenomena. Tanriöver and Şansal (2017) investigated the educational programs of all 56 design departments. Through interviews with professors, the authors recorded the main problems in lighting education in that context: lack of adequate teaching facilities (such as well-equipped laboratories), shortage of mandatory courses on the subject, low course hours, overcrowded classes, little or no cooperation with the industry, and difficulties in organizing visits to well-lit buildings. The research concluded that one possible way to improve lighting education would be to give students the opportunity to gain practical experience, helping them effectively use light as a tangible design element.

In the Brazilian context of Sousa et al.'s (2023) research, two articles addressed issues related to faculty, namely Vianna, Pires, and Silva (2012) and Martau (2015). Vianna, Pires, and Silva (2012) conducted an analysis based on interviews with professors from architecture schools in Rio Grande do Sul, focusing on the proposed activities and computational tools used to assist in lighting education. As a result, the interviewed professors reported that these resources are only used in the context of Environmental Comfort courses. Therefore, there is no encouragement from Architectural Design

professors to use computer simulation tools for light. Additionally, the problem of a lack of connection between Environmental Comfort and Architectural Design courses is presented. The authors conclude that computer graphics resources, along with traditional teaching methods, contribute to exploring lighting effects and enhancing learning through the application of innovative teaching methods. Martau (2015), in his research, developed an extensionist teaching activity in three stages: sensitizing participants through a film; lectures on sustainability in lighting, automation, and lighting of historical buildings; and case studies of successful projects. It was concluded that teaching practice in lighting education should highlight user aspects in design and sensitize students to propose lighting strategies capable of generating an emotional experience.

As for students, eight studies identify them as the research population. Gonçalves and Duarte (2006) highlight the importance of integrating sustainable architecture education with environmental comfort and energy courses. The authors point out a disconnect between design studios and the application of basic knowledge of environmental comfort, energy efficiency, and sustainability in Brazilian schools. They emphasize that this **disconnection harms students'** training and, consequently, the professional practice of architects and urban planners. Furthermore, they emphasize that the impact of lighting on energy consumption should be a central point in education, encouraging practices that aim at sustainability. Faria (2014) analyzes the impact of using computational tools in daylighting education. The author concludes that computer simulation facilitates students' understanding of the **relationship between natural light and the built environment,** aiding them in developing more efficient and integrated designs. This digital approach is seen as an effective way to complement traditional education and prepare students for the technological challenges of professional practice. Studies by Giuliani et al. (2019, 2018), Sokół and Martyniuk-Pęczek (2019), and Lo Verso et al. (2021), derived from the DAYKE project, explore the knowledge of daylighting **among European students**. These studies reveal a significant **lack of knowledge about metrics, regulations, and terminology,** as well as difficulties in implementing natural light in the design process. The research indicates that these deficiencies can limit the effectiveness of architectural projects and highlight the need for more robust and integrated training in lighting. Atanasio, Pereira, and Pereira (2007) developed a Virtual Learning Environment (VLE) focused on the propagation of light and the interferences caused by modifications in the main architectural variables. The VLE aims to **address students' lack of understanding of the light phenomenon** and provide more solid and practical learning about the use of natural light in architectural projects. This digital tool allows students to experiment with and better understand the effects of light in a controlled virtual environment. Similarly, Matos, Pavani, and Scarazzato (2022) present the advantages of using scale models or physical models associated with the use of High Dynamic Range (HDR) images for lighting analysis. They validate the qualitative and comparative

analysis between HDR images, physical models, and the corresponding real environment. This practical approach allows students to develop a deeper and applied understanding of lighting concepts, effectively integrating theory and practice. Finally, Schmid (1999) proposed a graphical method for estimating lighting levels in the early stages of architectural design. This method aims to raise **students'** awareness of daylighting, allowing them to evaluate the luminous performance of indoor environments practically and immediately. Although labor-intensive, this method provides a solid foundation for students to understand the principles of lighting from the initial stages of design.

Thus, a summary table was created considering the categories, the authors, and what each presents as a theory in relation to the analysis, highlighting the crucial points.

Table 4 - Summary table regarding the categories and the studies of the authors

Category of Analysis	Author and Year	Study Theory
Category 1: Lighting Education	Boyce e Mcibse (2006)	Advocate for lighting as a significant "message" for the user and the integration of natural light in projects.
	DiLaura (2007)	Emphasizes the need for **technical and practical** education due to contemporary dependence on technology in lighting.
	Bech-Larsen, Linnebjerg e Mullins (2018)	Map the necessary competencies for training aligned with the demands of the **productive sector.**
	Lam (2021)	Highlights the importance of the relationship between **light and human health** and the incorporation of digital thinking and research in lighting design.
	Gonçalves e Duarte (2006)	**Integration** of lighting with **environmental comfort** and sustainability in the design process.
	Mülfarth (2018)	Necessity to address lighting along with other **design variables.**
	Faria (2014)	Impact of **computational tools on daylight education**, facilitating the understanding of the relationship between natural light and the environment.
	Phillips (1956)	Criticizes the **lack of connection between lighting projects and architectural works**, suggesting joint activities between faculties.
	Navvab (2014)	Highlights the importance of **computer simulations** as evaluation tools in lighting education and design.
	Mansfield (2017)	Identifies three crucial points in lighting education: **reading, collaborative courses, and online content**.
Category 2: Graduates and the University	Bogo (2002)	Encourages **experimentation** and stimulating student inquiries by faculty.
	Tanriöver e Şansal (2017)	Investigation of educational design programs and issues in lighting education, **suggesting improvements through practical experience.**
	Vianna, Pires e Silva (2012)	Analysis of the use of computational tools in lighting education points out the lack of connection between **environmental comfort and architectural design disciplines.**

	Martau (2015)	Teaching practices in lighting education should highlight user aspects in the design and sensitize students to propose lighting strategies capable of generating an **emotional experience.**
	Gonçalves e Duarte (2006)	The authors emphasize that the disconnect between design studios and the application of knowledge on **environmental comfort, energy efficiency, and sustainability** hinders the training of students and the professional practice of architects and urban planners in Brazilian schools.
Category 3: Students	Faria (2014)	Impact of the use of computational tools in daylighting education: Facilitating the development of efficient and integrated designs.
	Giuliani et al. (2019, 2018), Sokół e Martyniuk-Pęczek (2019), Lo Verso et al. (2021)	Exploration of knowledge about daylight among European students, revealing deficiencies in **metrics, regulations, and terminology.**
	Atanasio, Pereira e Pereira (2007)	Development of a Virtual Learning Environment (VLE) to address students' lack of understanding of the **light phenomenon.**
	Matos, Pavani e Scarazzato (2022)	Use of scale models or physical models for lighting analysis, effectively integrating **theory and practice.**
	Schmid (1999)	Proposal of a **graphical method** for estimating lighting levels in the early stages of an architectural project.

Source: Prepared by author.

From then on, in alignment with this research and as a support for analysis in cross-referencing data with interviews, questionnaires, and interactions with students, the articles were reviewed to identify the themes and contents presented. This analysis was conducted based on the frequency of term occurrences, considered as the foundation for the sufficiency of a lighting project. As demonstrated in the table (Table 5), "Electric lighting" was the most frequently occurring term, with 39 mentions, emphasized by authors such as Rea et al. (2012) and Schmid (1999), reflecting its integration as a fundamental element in architectural projects. "Daylight," with 34 occurrences, is also widely discussed, mainly by Dilaura (2007) and Phillips (1956), indicating the necessity to complement natural light.

Standards and regulations are cited 12 times by authors such as CIE (2020) and Gonçalves & Duarte (2006), highlighting the importance of compliance and safety in lighting projects, as well as issues related to energy efficiency and sustainability. Technical terms like "Simulation" or "Computer simulation" appear 16 times and are essential for accuracy and evaluation in projects, as cited by Navvab (2014) and Martau et al. (2020). "Sustainability" is mentioned 11 times, underscoring its relevance in modern lighting projects, as pointed out by VanZee (2014) and Sokół and Martyniuk-Pęczek (2019).

"Physiological aspects" are cited 8 times, showing the importance of understanding how lighting affects human health, with contributions from Rea et al. (2012) and Boyce & Mcibse (2006). "Energy efficiency" is mentioned 6 times, highlighting the need for energy-efficient solutions according to CIE (2020) and Giuliani et al. (2020). "Representation methods (graph)" appear 3 times, cited by Phillips (1956) and Scarazzato et al. (2005), and are crucial for accurate representation in lighting projects. "Light calculation" is cited 2 times, by Boyles et al. (2009) and Frank et al. (2009), being essential for the quantitative evaluation of light in projects. The term "Artificial lighting" did not have specific occurrences highlighted in the updated table.

Table 5 - Table of term counts and occurrences in the SLR

Terms	Occurrences	Importance factor (%)	Author, year
	Literature		
“Eletric lighting” “Artificial lighting”	39	29,77%	REA et al., 2012; SCHMID, 1999; SOKÓŁ & MARTYNIUK-PĘCZEK, 2019; LO VERSO et al., 2021; ATANASIO, PEREIRA & PEREIRA, 2007; REINHART & WEISSMAN, 2012; VANZEE, 2014; FARIA, 2014
“Daylight”	34	25,95%	DILAURA, 2007; PHILLIPS, 1956; MARTAU, 2015; ZAEVA-BURDONSKAYA & NAZAROV, 2018; NASYBULLINA et al., 2021; VALDEZ et al., 2008; BERARDI, PIETROFORTE & EL-KORCHI, 2014; KARPEKO, 2020; GUSTINA, 2011; VANZEE, 2014
"Simulation" or "Computer simulation"	16	12,21%	NAVVAB, 2014; VALDEZ et al., 2008; VANZEE, 2014; FARIA, 2014; MARTAU et al., 2020; LO VERSO et al., 2021
“Standards and Legislation and Regulations”	12	9,16%	CIE, 2020; GONÇALVES & DUARTE, 2006; TANRIOVER & ŞANSAL, 2017; DAVIS & HU, 2021; LO VERSO et al., 2021; SOKÓŁ & MARTYNIUK-PĘCZEK, 2019; PHILLIPS, 1963; REA et al., 2012; CIE, 2020; ZISSIS et al., 2021; LO VERSO et al., 2021; TANRIOVER & ŞANSAL, 2017; PHILLIPS, 1963; MARTAU et al., 2020
“Sustainability”	11	8,40%	VanZee, 2014; Sokół e Martyniuk-Pęczek, 2019; Gonçalves e Duarte, 2006; Mülfarth, 2018
"Physiological Aspects"	8	6,11%	REA et al., 2012; SOKÓŁ & MARTYNIUK-PĘCZEK, 2019; LAM, 2021; MARTAU et al., 2020; MANSFIELD, 2017; GUSTINA, 2011; BOYCE & MCIBSE, 2006
“Energy Efficiency”	6	4,58%	CIE, 2020; Gustina, 2011; VanZee, 2014; Bandeira e Scarazzato, 2018; Mansfield, 2017; PHILLIPS, 1963; GIULIANI et al., 2020; DAVIS; HU, 2021; BOYCE; MCIBSE, 2006; MARTAU e HENRICH, 2020; IEA, 2022; IEA, 2020; Sokół e Martyniuk-Pęczek, 2019; LEE; AWBI, 2004
"Representation Methods (graph)"	3	2,29%	PHILLIPS, 1956; SCARAZZATO et al., 2005; REINHART & WEISSMAN, 2012; GUSTINA, 2011
“light calculation” “photometry” "photometric units"	2	1,53%	BOYLES et al., 2009; FRANK et al., 2009; REINHART & WEISSMAN, 2012; SOKÓŁ & MARTYNIUK-PĘCZEK, 2019; VANZEE, 2014

Source: Prepared by author.

In addition to the presented findings and the new analyses conducted from the systematic literature review, it is important to highlight what aligns with and will be analyzed in the interactions with faculty and students, specifically regarding what the authors discuss about active teaching methodologies. According to Sousa et al. (2023), among the reports of teaching experiences in lighting, 30% of the articles clearly defined the methodologies adopted, **all of which were based on active methodologies.** Three studies used "Problem-Based Learning"[14] (Hansen and Kofoed, 2017; Siniscalco, Bellia, and Marchesi, 2021; Valdez et al., 2008), one utilized "Project-Based Learning"[15] (Berardi, Pietroforte, and El-Korchi, 2014), and another "Experience-Based Learning"[16] (Arnkil and Pyykkö, 2018). The clear definition of methodologies reflects the educators' intention to systematize the teaching-learning process and position students as the main actors in their own learning.

Regarding the main tools identified, computational resources were the predominant tool used in simulations across all studies with technical, non-functional compositional, or hybrid approaches. Of these, 64% combined computational simulations with other tools such as physical models, drawings, and real measurements, while 36% used only computational simulations. This indicates a growing trend towards diversifying didactic experiences for students, especially in architectural projects.

Finally, in a brief comparative analysis between the Brazilian and international realities, foreign research exhibited a characteristic of a deep understanding of light behavior and its interactions with the built environment. International studies also emphasized the complexity and multidisciplinary nature of lighting education. Researchers argued that training should include interdisciplinary practices, encompassing technical approaches as well as compositional and symbolic aspects of lighting. It is crucial for educational programs to incorporate new technologies and respond to market demands and scientific advances in the field of lighting. In the Brazilian context, there was a noted lack of in-depth research on lighting education, with most publications focusing on reports of pedagogical experiences without a comprehensive discussion on educational practices in the country.

[14] Problem-Based Learning is a strategy in which students are encouraged to solve a problem by following steps that involve identifying the problem, constructing a hypothesis, collecting data, discussing (involving re-evaluation of concepts and reflection on their own learning), and concluding (Gil, 2020).

[15] Project-Based Learning is also based on a problem to be solved by the students, but it necessarily includes a task to be performed that corresponds to a real situation. This methodology focuses on developing skills necessary for real-world activities, such as communication, time management, teamwork, decision-making, and leadership (Gil, 2020).

[16] Experience-Based Learning is an approach that values students' prior experiences, requiring the involvement of the whole person—intellect, feelings, and senses. New learning is achieved through continuous reflection on previous experiences to add and transform, aiming for a deeper understanding of the content (Foley, 2020).

The sequence of the present thesis, defended and approved on September 6, 2024, will be available starting September 6, 2026, at the author's request and with the agreement of her advisor.

A sequência da presente tese defendida e aprovada no dia 06/09/2024 estará disponível a partir do dia 06/09/2026, por solicitação da autora e em concordância da sua orientadora.