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STUDY OF ENERGY AND TECHNOLOGICAL CATEGORIES OF BUILDING, FOR COMPREHENSIVE TRAINING IN THE ARCHITECTURAL DESIGN PROCESS

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ABSTRACT

Purpose: analyse, describe and systematize categories and variables related to technological and energy aspects in building, in favour of comprehensive approaches for the training of design process

Methodology: the paper proposes a descriptive-interpretative work. It unfolds according to three stages: conceptual, operative and interpretative. Bibliographic analysis, surveys, focus-groups, and post-active assessment are used as theoretical-conceptual tools.

Findings: The inclusion of technological-energy efficiency, climate change and the impact of the built environment in the teaching of the design process cannot occur in an additive way, but rather in an integrated and systemic manner. Therefore, we must recognize and work on the training of design thinking, interrelating knowledge, abilities, positioning and values, towards greater cultural coherence, technological-energy efficiency and environmental awareness.

Research limitations/implication: The limitation of approaching a complex process (such as the teaching of architectural design) from a determined set of variables is recognized. Likewise, its explanation is valuable for reflecting on teaching (and professional) actions and instituted practices.

Originality/Value of paper: The originality of the work lies in presenting foundations and approach options to integrate energy and technological efficiency as a constitutive and unavoidable part of architectural design.

KEYWORDS: energy, design process, training, architecture, built environment

ESTUDIO DE CATEGORÍAS ENERGÉTICAS Y TECNOLÓGICAS EDILICIAS, PARA LA FORMACIÓN INTEGRAL EN EL PROCESO PROYECTUAL ARQUITECTÓNICO

RESUMEN

Objetivo: analizar, describir y sistematizar categorías y variables relacionadas a los aspectos tecnológicos y energéticos en la edificación, en favor de abordajes integrales para la didáctica del proceso proyectual.

Metodología: El artículo propone un estudio descriptivo-interpretativo, desarrollado a partir de tres etapas: conceptual, operativa e interpretativa. Como herramientas teórico-conceptuales, se utiliza el análisis bibliográfico, encuestas, grupos focales y la autoevaluación posactiva.

Conclusiones: La inclusión de la eficiencia tecnológico-energética, el cambio climático y el impacto del ambiente construido a la enseñanza del proceso proyectual no puede darse en forma aditiva, sino integrada y sistémica. Por lo tanto, debemos reconocer y trabajar sobre la formación del pensamiento proyectual, interrelacionando conocimientos, habilidades, posicionamientos y valores, en dirección a una mayor coherencia cultural, eficiencia tecnológico-energética y consciencia medioambiental.

Limitación / implicación de la investigación: se reconoce la limitación de abordar un proceso complejo (como lo es la enseñanza del diseño arquitectónico) desde un conjunto determinado de variables. De todas formas, su explicitación es valiosa para reflexionar sobre el accionar docente y profesional y desnaturalizar prácticas instituidas.

Originalidad / Valor del artículo: La originalidad del trabajo radica en presentar fundamentos y opciones de abordaje para integrar la eficiencia energética y tecnológica como parte constitutiva e ineludible del diseño arquitectónico.

PALABRAS CLAVE: energía, proceso proyectual, enseñanza, arquitectura, ambiente construido

1. INTRODUCTION

The paper presents contributions in order to reduce building energy demand, and its resulting costs reduction (for the user and the State) and impacts on the environment and climate. In this regard, for more than a decade the authors and research team have been working, from Argentina, on public and private dissemination and training in regulatory frameworks and technological-construction requirements to improve energy efficiency (EE) and quality of habitability –both in new and built buildings– (Rodríguez, 2015; Rodríguez et al., 2017; Fernández, Rodríguez, Fiscarelli, 2021). Since then, studies on technological improvements have been increasingly prolific (Barbaresi et al., 2020; LETI, 2020; Mesquita & Ripper Kós, 2017; Rodríguez, et. al., 2016; San Juan, et al., 2023;), while consumption values have continued to rise (Ahmad & Zhang, 2020; BEN, 2023; Subramanian et al, 2022).

For this reason, and given the necessary support and promotion of Public Management for the treatment of technological improvements in new and existing construction (Rodríguez, 2017), the authors have committed to work on the preliminary stage of the design in university teaching, towards a greater and better integration of technological aspects, in the structuring and creative instances of the architectural process.

To this end, progress and results are presented within the framework of research promoted by the National Scientific and Technical Research Council (CONICET: Consejo Nacional de Investigaciones científicas y Técnicas, Argentina) in contribution to the 2022 Strategic Themes: Sustainable Technological and Social Development, and transversally, Environment and sustainable Development (Rodríguez, 2023-2026; Rodríguez, 2023-2025) and a Research Group Project, funded by the National University of the South –Bahía Blanca, Argentina– (Fernández and Rodríguez, 2022-2026) *PROARQ* program (DGyT, UNS) on a priority research topic on *innovation technology and architecture*, whose objective establishes "building a vision of sustainability applied to architectural knowledge" (Res. CSU 553/2021, Appendix I. page 4). Through these studies, approaches to EE, technology and environmental responsibility are promoted in architectural construction from its initial design stage, in the undergraduate degree. Working on academic and scientific research on teaching practices, design knowledge is questioned from its technical dimension, with a focus on the energy-technological aspect; also anticipating potential conflicts, reflecting on the energy-built habitat dependence, and collaborating in "the training of responsible people, with ethical and supportive awareness, reflective, critical, capable of improving the quality of life and consolidating respect for the environment" (L.E.S., 1995, Art. 3).

Thus, the paper presents: the *research positioning*, *background* on the subject, delimitation and *proposal*; the *methodological framework*, its tools, stages and activities; the results and discussion, related to dimensions for the architectural design training, characteristic actions in the design process, categories for the integration of technological and energy dimensions to design process and definition of variables for each category. Finally, *conclusions* are exposed, in order to reflect on energy, climate and the impact on the built environment, the classroom activities, and future commitments.

2. POSITIONING, BACKGROUND AND PROPOSAL

Related to the (pedagogical) *formation of design thinking*, in general, the different areas and subjects that make up each study plan are organized according to their own epistemological logic; which, also, are grouped into an older disciplinary field, conditioned by particular educational and institutional traditions. Thus, the most significant didactic requirement posed by *design knowledge in architecture* refers to the integration of knowledge, procedures and conditions of its own and interdisciplinary order, coming from science, art and technology.

In this regard, Dr. Cravino (2020a) delves into the distinction between knowledge about, for, and in the design. In her epistemological study, she highlights the value of *science* for the argumentative field and *design* and *art* for empirical evidence. Likewise, she affirms that the design disciplines are in an intermediate position, together with the field of *technology*, having two interrelated products: knowledge and artifact.

Therefore, it is noted that each curricular space in higher education interrelates the various fields, and establishes different dynamics that prioritize one over another. As a classification, it can be recognized that the several subjects propose teaching about, for and through design (Rodríguez, 2023):

-*Teaching about architecture and design*: it refers to inter and transdisciplinary treatment, studying architecture from diverse contextual perspectives –which provide meaning and legitimation– and professional intervention spaces;

- *Teaching for architecture and design*: it refers to the technological and topological work, which allows its representation, production and materialization in the various stages of the architectural design;

-*Teaching through architecture and design*: to advance in the design competences –tacit and specific– that constitute the gestation of the idea, its prefiguration and verification, at the different levels of complexity and scales of action.

If a comprehensive treatment of design is considered, it is important that each subject contributes (at different extent), to the teaching about, for and through design competencies. For this reason, the research presented in this article challenges the tradition of technical subjects teaching, mainly based on logic of methodical rigor, with only deductive approaches and linear didactic proposals (in tune with the methods of modern science). This fact, sustained over time, deserves to be reviewed in order to enhance undergraduate disciplinary training, in favour of adjustments that allow the incorporation of mediational cognitive strategies, construction and collective resignification, related to the abilities and competencies that the design disciplines demand. In this regard, it is significant to work on the dynamic balance between science, technology and art through the design process, *for* future professional practice and *from* didactic practice in higher education. And thus, acting with the greatest possible coherence between means and fines, complementing the virtues of the prescriptive and the critical-reflective (Rodríguez, 2020), of science, technology, design and art, in each context, circumstance and proposal.

2.1. Background on the subject

The participation of sustainability and technological-energy efficiency on the teaching of design presents a considerable role in current study programs (Blasco Lucas, 2013; Faludi et al., 2023; Noel et al. 2023; Watkins et al., 2021). However, backgrounds that develop the didactics of architectural design process through the technical dimension are less frequent. In this regard, Gerardi and Esteves (2002; 2004) have investigated the design process for sustainable architecture, highlighting its technical, theoretical and methodological dimension. Besides, they have carried out link actions between research projects and undergraduate training, in a teaching experience that articulated the process of design prefiguration and the area of technologies and energy. In addition, San Juan (2013) has worked from several angles of energy, technology and social construction of habitat, promoting numerous research and teaching activities (undergraduate and postgraduate) in contribution to the integrated architectural design. For her part, Blasco Lucas (2022) proposes bases to study a model of the creative process in architectural design, according to concepts of sustainability and life cycle of materials, components and the building as a whole. Moreover, Bellot and Fiscarelli (2021; Fiscarelli and Bellot, 2023) analyze the teaching of facilities subjects, in order to build didactic strategies that integrate technical training and architectural design. While Dr. Cravino (2020b), based on her doctoral research, carries out an analysis from a historical perspective on the scientific, technological and technical subjects in the teaching of the Architecture degree at the UBA, to reflect on its transformations, characteristics and intentions.

Regarding own developments on the teaching of the technical dimension and sustainability, the article "The technical dimension in project teaching: between science and design" (Rodríguez, Fiscarelli, Fernández, 2022) stands out; where the qualities of the technical dimension of the architectural design and its teaching are studied, in relation to its argumentative and/or exploratory relevance. Additionally, in the article "Energy efficiency and sustainability as an exercise in coherence: research and teaching proposal for design knowledge" (Rodríguez and Fernández, 2021) foundations are explained in relation to investigating undergraduate teaching to promote didactic practices in the integration of design technology, theory and methodology.

2.2. Delimitation and proposal

In short, through previous studies, a notable fragmentation can be recognized in the development of the training design process, separating the technical areas from the design and planning ones. Thus, technological knowledge is usually added to a rather abstract, simplified, reduced preliminary design. And, although this dynamic is established as a validated practice (reinforced in the study plans and our teaching roles), one could also think of a way -as an alternative- to materialize architectural designs from the interrelation of their technical, theoretical and methodological dimensions (Sarquis, 2007); foreseeing, in this case, future energy and material impacts of the built environment.

Consequently, the article aims to *analyse, describe and systematize categories and variables related to technological and energy aspects in building, in favour of comprehensive approaches for the training of design process*.

In summary, based on this objective, it is intended to address the technical-energetic dimension of the building and its urban impact from the initial stage of configuration in its undergraduate teaching-learning, collaborating in the integration of the technical, the theoretical and the practical in the design process. Through this, the construction of a more coherent positioning is enabled; at the same time responding to the complexity that characterizes the contemporary physical and sociocultural context (Meirinhos & Portela, 2023) and the logic of design thinking, overcoming positivist thinking (fragmented, additive, linear, reductionist).

3. METHODOLOGY

A *qualitative methodology* is used, based on the articulation of disciplinary and transdisciplinary bibliographic analysis, with the validation in the crucial frame of reference: the classroom. Therefore, in addition to the use of *bibliographic analysis*, *surveys*, *focus-groups*, and *post-active assessment* are used as theoretical-conceptual tools.

Furthermore, the study proposes a *descriptive-interpretative* work. It unfolds according to three stages: conceptual, operative and interpretative (Table 1).

3.1 Methodological tools

- *Bibliographic analysis* is used, as main data collection and classification technique for the conceptual stage (both from primary and secondary sources), being complemented with surveys.

- The *surveys* are used for a quick and agile collection of the opinion and knowledge of professors (diachronically), in order to classified and validate the theoretical assumptions.

- *Focus-group* is an appropriate strategy both for gathering opinions and promoting collective reflection. Through this technique, personal information was collected, analysed and reflected upon simultaneously.

- The *post-active assessment* is carried out by the researchers, according to the classroom experience, based on participant observation (also as professors). This strategy enables analysis, reflection and self-assessment, synthesizing results that are used as input in later works.

3.2. Research stages and activities

i) The first stage –conceptual– refers to theoretical reviews, related to the collection and analysis of information, the formulation of research questions, particular objectives and activities; studying the state of the art and defining the theoretical framework and analysis categories.

The activities are carried out according to bibliographic analysis, researchers proposal and its confrontation through surveys to 4 professors[*], in order to classified the *dimensions for the architectural design training*, described the *characteristic actions in the design process* and propose *categories for the integration of technological and energy dimensions to design process*.

[*] (It represents the 50% of Architectural Design professors from Architectural degree, National University of the South, Argentina –considering that one of the researchers is also an associate professor–).

ii) The second stage –operative–, is carried out in the classroom (with 28 students[**] of the 3rd. year of Architectural degree, National University of the South), according to 3 main activities.

The first activity is hold by researcher's explanation about the study framework, and main aspects about design thinking, comprehensive training and energy and technological efficiency for architecture. Finally, a rhetorical question is shared: "How to stimulate an integrative design perspective, which understands energy and technological aspects as a constitutive part of the design process?".

The second activity consists of: "Analysing and describing variables related to technological and energy aspects in the building, in order to improve their integration in the design process". Therefore, students are divided in sub-groups of 8 to 10 pupils, each one coordinated to a teacher assistant, in order to discuss about design variables for the assigned category: *cultural coherence*, *energy and technical efficiency* or *environmental awareness*.

For the third activity, each group presents and debates its proposed variables to the hole classroom, through the "focus group" technique. And the researchers take notes on the board, synthesizing the results.

[**] (The number of students is barely representative –approximately 12% of the middle cycle–. But it is acceptable, considering its objective of confronting the researchers' proposal, in a pilot study).

iii) In the third stage –interpretative–, a post-active assessment is carried out by the researchers, whose recover the theoretical assumptions (dimensions, characteristics and categories proposed) and confront them to reality observed. Then, it is compared to the results of focus group activity. As a result, a hermeneutical interpretation is described, defining variables for each category.

STAGE	*PURPOSE*	*TOOLS*	*PARTICIPANTS*
CONCEPTUAL	Obtaining and processing information to determine the contents, the theoretical-conceptual tools and the intervention strategies	-Bibliographic sources analysis -Surveys	-2 Researchers -4 Professors
OPERATIVE	Recognition and systematization of interrelated variables in architecture and design didactics, for energy efficiency and technology	-Focus-groups	-2 Researchers -3 Teachers assistants -28 Students
INTERPRETIVE	Reflection and synthesis of experiences and results	-Post-active assessment	-2 Researchers

Table 1. Stages, purposes, methodological tools and participants

4. RESULTS AND DISCUSSION

As it was described in Table 1, the present study is developed in an initial office stage, a subsequent stage of field work in the classroom and a final office stage. Thus, the results are related to definition of: the theoretical framework (*i. Dimensions for the architectural design training; ii. Characteristic actions in the design process*); categories of analysis (*iii. Categories for the integration of technological and energy dimensions to design process*); and its variables (*iv. Definition of variables for each category).*

4.1. Dimensions for the architectural design training

To analyse didactic practices in architecture and project –referred as well as "design"–, it is important to establish its significant dimensions in the educational relationship. The dimensions adopted for the study of comprehensive training processes (Rodríguez, 2020) are described as:

- *Disciplinary knowledge*
  This area includes aspects such as content accumulation, comprehension and classification; in reference to knowledge recovery, identification of situations and problems, exemplification, hierarchies and priorities establishment, resources allocation, information sequencing.
- *Design abilities*
  This area includes the analysis and synthesis, the design resources; in reference to decomposition into material or conceptual parts, redefinition of problems, criticism of assumptions, promotion of creative ideas, formulation and application of strategies and procedures, production of didactic elements, completion of the task, development monitoring, assessment of proposed solutions.
- *Interpersonal skills*
  This area includes communication skills, cooperation and contribution to the course; in reference to socialization skills, handling of symbolic transmission tools –oral, written, graphic–, the exercise of appropriate skills in goal orientation, the commitment and responsibility, construction of autonomy –self-motivation, impulsivity control, perseverance–, concentration, the balance of analytical , creative and practical skills (fig. 1).

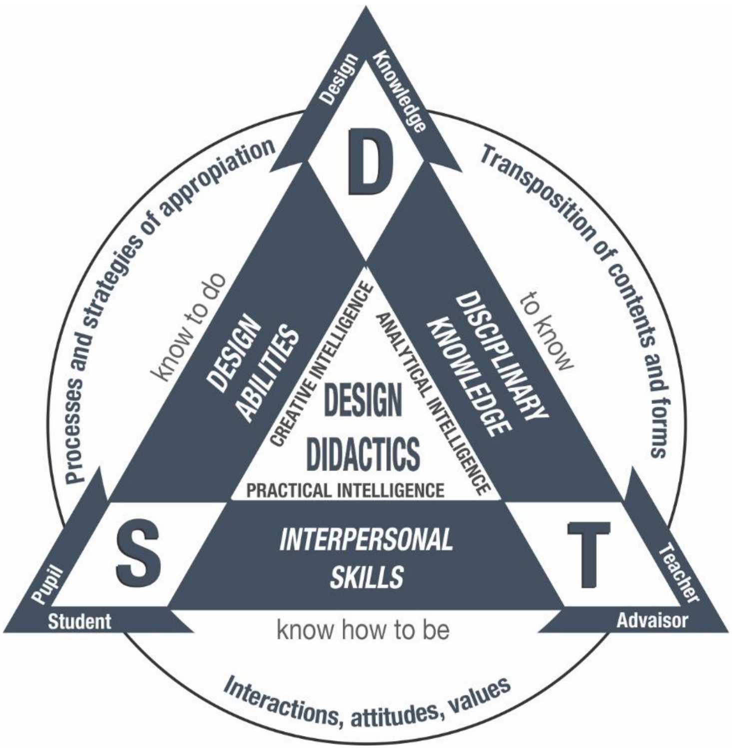

Figure 1: Comprehensive training in architecture and design
Source: Own elaboration, adapted from Rodríguez (2020)

4.2. Characteristic actions in the design process

Even when external conditions are suitable for carrying out critical-reflexive educational practices, sometimes it is not enough and teachers get side-tracked in the daily dynamics of studio classroom and/or institutional demands. So, it is also essential to adjust the gaze in looking on propitious skills for designing, taking the emerging situations of the classroom as didactic instances, in favour of training in its various aspects.

Citing an example of this, Bryan Lawson (2002) alerts about the conflict between the design processes complexity and the simplistic tendency to measure performance and knowledge acquired. How do you measure complex and multidimensional performances in linear terms? As teachers, it is significative to remember that the function of evaluation is not to qualify but to assess in order to adjust and improve (Rodríguez, 2020). Therefore, the concerns should not prioritize institutional paradoxes of evaluation-qualification, but rather the cognitive contributions for complex thinking, through the characteristics that the design process offers itself.

Thus, Zeisel (1984, pp. 5-15) has proposed five characteristics of designing, as useful tools for understanding what designers do:

i) The complex designing activity interconnects three constituent activities: imaging, presenting, and testing
ii) Information used in designing tends to be useful in two ways: as a heuristic catalyst for imaging and as a body of knowledge for testing
iii) Designers continually modify predictions about their final results in response to new information and insight. The design process is thus a series of conceptual shifts or creative leaps
iv) Designers aim to reach one acceptable response within a range of possible solutions. This domain of acceptance is measure largely by how well a product is adapted to its environment and how coherent constituent parts of the product are with one another
v) Conceptual shifts and product development in design occur as the result of repeated, iterative movement through the three elementary design activities

Reinforcing this idea, characteristics of design process are synthetized as: *reflection in action, complexity, creative and random fact, migration of ideas [in]to representations, and definition by successive approximations* (Rodríguez and Fiscarelli, 2021).

Analysing these aspects, it becomes clear that the *problem-solution* relationship stands out (Dubberly, 2022), both in design process and in its teaching. Lawson (2002) states that "design problems and solutions are inexorably interdependent" (p. 119). And though problems may suggest certain features of solutions, these solutions in turn create new and different problems (fig. 2). In addition, the author summarises important characteristics, warning us about not to take it as a comprehensive list of discrete properties, but to take it together as a sketch of the nature of design as it seems today.

Characteristics of design problems:
1) cannot be comprehensively stated
2) require subjective interpretation
3) tendency to be organised hierarchically

Characteristics of design solutions:
1) There are an inexhaustible number of different solutions
2) There are no optimal solutions to design problems
3) Design solutions are often holistic responses
4) Design solutions are a contribution to knowledge
5) Design solutions are part of other design problems

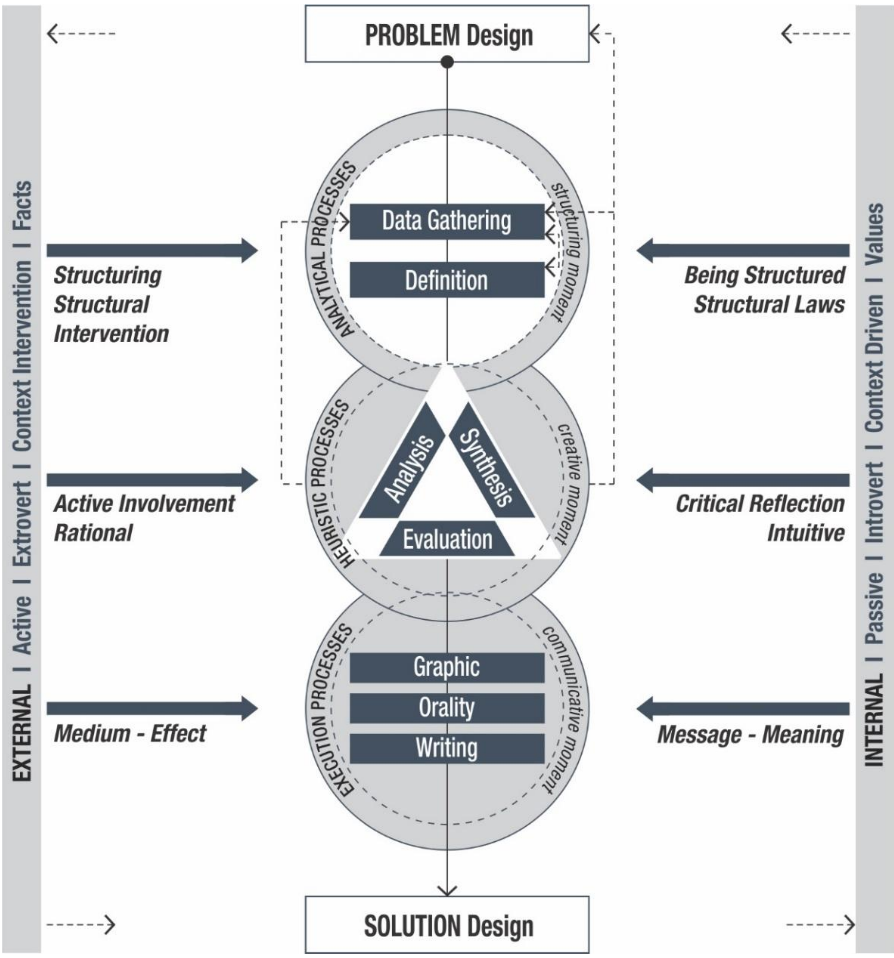

Figure 2: Problem-solution interdependence in the design process
Source: Own elaboration, based on data from Lawson (2002) and Foque (2010)

4.3. Categories for the integration of technological and energy dimensions to design process

It is stated that the design process and its teaching are based on complex and interrelated logics. Thus, in order to propose classification categories of technological and energy variables, related to comprehensive design training, it is integrated:

-The *theoretical, methodological and technical dimensions of the design*, as an object of knowledge (Sarquis, 2007). It refers to the framework that gives it conception and meaning, the configuring procedure for its creation and the construction of its maximum state of concretion, respectively.

-The interrelated *cultural, technological-energy and environmental aspects for sustainable architecture* (Rodríguez, 2021). It integrates the environmental, the economic, the energy, the technological, the political, the ethical, the institutional, the human, the social; and analyses the sustainable in sustainable architecture, energy in the built habitat and natural resources in the design.

-And scales of didactic approach from the pedagogical proposal of the South Architectural Studio UNS (Fernandez et al., 2019), in relation to the *site* (place, being, inhabit), the *program* (the connection with the user and their demands) and the *matter* (the reciprocity between the parts, the geometric, the material, the formal, the dimensional, the constructive).

In reinforcement of these dimensions, it is recognized that there is no architectural design without a place. The specificity of the site forces a site rooted, contextualized and responsible thinking. Observation and reading of the place also build a conception of the possible, an appreciation of one's own history. Thus, local variables (territory and culture) and own variables (near and proximate) contribute to the learning of architecture, for the local as well as global scale.

Nor is it possible to conceive the architectural design without a precise technical awareness of materiality. The design (also called as project) represents the concrete. It can be imaginary, non-specific or indeterminate, but never immaterial. Each representation responds to the material universe of architecture, to the things of the discipline (raw materials, materials, artisanal products, industrial products, technologies).

At the same time, programs are built to articulate the steps from the site to the material in its connection with the user. In its exercise, scenarios are agreed upon that anticipate or decode recipients' demands, configuring both the uses and the technological means of projection. Spatial, distributive, functional, morphological, material, technical, compositional, and expressive structures are conceptualized. An observed reality is analysed and problematized, towards the design of a possible and desirable reality.

Based on these interrelated aspects, 3 general categories are proposed (fig. 3), in contribution to the organization and addressing the multiplicity of variables present in the design process and its teaching-learning.

- *CONDITIONS (habitat appropriation). Cultural coherence. Site. The symbolic, the sensitive, the contextual. Habits, the urban interactions.*
- *MEANS (habitat projection). Energy and technical efficiency. Program. Technological capacity to transform the environment. Inhabit, the uses.*
- *AVAILABILITIES (habitat construction). Environmental awareness. Matter. Energetic and material supply. Habitability, the buildings configuration.*

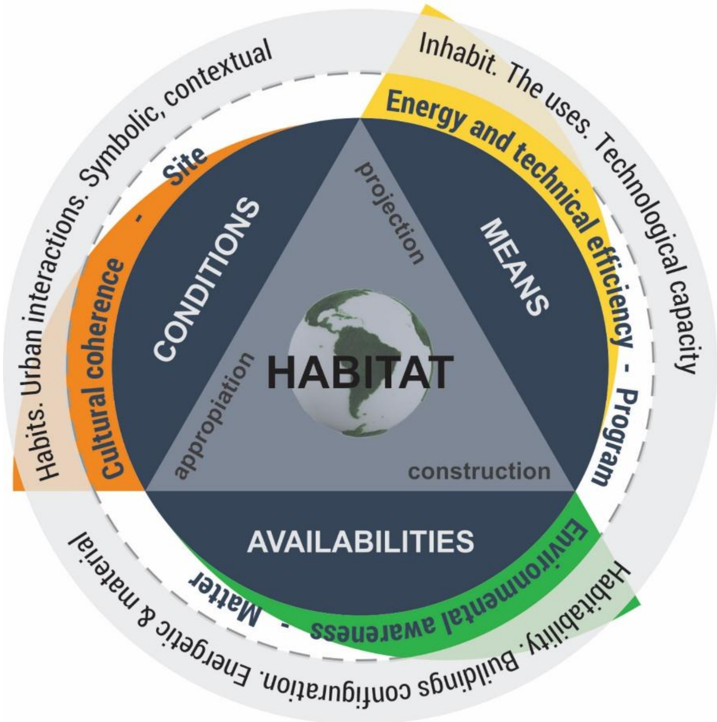

Figure 3: Interdependent categories in the design process
Source: Own elaboration

4.4. Definition of variables for each category

The variables for each category are classified from the focus group work records (fig. 4) and their subsequent analysis and adjustment. Additionally, it is clarified that its description is not intended to be absolute or closed. In fact, the presentation of the different options proposed by the students is considered valuable, while the academic community is invited for its later expansion.

- *CONDITIONS (habitat appropriation). Cultural coherence. Site. The symbolic, the sensitive, the contextual. Habits, the urban interactions.*

-Customs and social organizations (the construction of everyday life)
-Territorial dynamics (geographies, flows, overlaps, intertwining)
-Dominant economy (exchange systems for goods and services)
-Political dimension (set of agreements and values)
-Institutional dimension (legitimations, validations)
-Normative and legal regulation frameworks (legislation, laws, codes, standards)
-Symbolic contexts (places, stories, tales, beliefs)
-Aesthetics (delights, tastes, differences/similarities)
-Sensitivities (physical, emotional, expressive. Individual relationship with reality)
-Semantic and semiotic capacity (interpretations of signs and meanings)
-Identity and pertinence (constructions of meaning and roots)
-Urban configurations (mobility, exchanges, nodes, peripheries, public spaces)

- *MEANS (habitat projection). Energy and technical efficiency. Program. Technological capacity to transform the environment. Inhabit, the uses.*

-Needs scheduling (repetition of models, innovation proposals)
-The User construction (idealization, typing, projection)
-Ethical dimension (values, positions, beliefs)
-Preconceived spaces, uses and dimensions (what we have, what we need)
-Disciplinary programming (habitat design and quality of life)

-Functionality of spaces (maximization, adaptability, added value)
-Flexibility of the space (adaptation to changes in context and circumstances)
-Use and potential of materials (alternatives)
-Energy costs (fewer resources, more benefits)
-Technical and technological procedures (Natural, artificial. Artisanal, industrial. Analog, digital)
-Domotics (automation for security and comfort)
-Communications and digital possibilities (potentialities in space-time)

- *AVAILABILITIES (habitat construction). Environmental awareness. Matter. Energetic and material supply. Habitability, the buildings configuration.*

-Life cycle: production/generation (construction, creation)
-Strategic use of natural resources, bioclimatic design (vegetation, sun, wind, water)
-Materials and labour cost and provision (rationalization of the demands, logistics)
-Topological capabilities (generation of shapes and environments)
-Material composition (constructive, formal)
-Life cycle: use/consumption (maintenance, sustenance)
-Well-being, perception of comfort (hygrothermal, visual, psychological)
-Climatic impact of the building on geography (natural and anthropic)
-Regeneration capacity of the resources (resilience, entropy)
-Life cycle: disuse/waste (demolition, residue)
-Impact by emissions (gases, waste)
-Reuse (retrofitting, recycling, reduction)

Figure 4: Focus group activity (Architectural studio course, National University of the South, Argentina)
Source: Own elaboration.

5. CONCLUSION

About energy, climate and the impact on the built environment

The motivation of the paper begins with the treatment of energy efficiency and the improvement of habitability conditions in the built environment, according to the mentioned backgrounds. Based on them, the need to work on awareness and training in society and each one of the actors involved in urban configurations (civil, political, professional) has been highlighted. Technical resolutions to improve energy and environmental conditions are available. Awareness for the care of natural resources is already an established issue. Today, the greatest requirement (and challenge) consists of obtaining the endorsement and political impulse of the municipal, provincial, and national administrations. Meanwhile, we continue to actively wait, participating in teaching and researching, in order to develop complementary academic and scientific contributions (such as those presented in this work).

Reflections on the classroom activities

Related to the professors, in survey activities, interest and knowledge about the different themes was exhibited. But they had barely organization and systematization on them. This fact makes it difficult to include Energy and Technological Efficiency in the initial design stages. The holistic view and management of complexity that design thinking demands –in integration of the analytical, creative and narrative– requires not only training and practice, but also reflection on action. Furthermore, the teaching for design thinking requires reflection on reflection on action and its subsequent conceptualization and classification.

As for the students, from the focus group activity, they demonstrated enormous interest in the treatment of cultural coherence, energy and technological efficiency and environmental awareness for the development of design. On the other hand, they also exposed lack of knowledge about basic aspects of architecture and sustainability (which is presumed in a middle degree student). Given this motivation scenario, it is stated that establishing the commitment to the sustainable design of the habitat, in this formative stage, is not only pertinent but also disciplinary appropriate and unavoidable.

Synthesis and future commitments

-In relation to *energy resources and buildings*, the commitment to disseminate, train and raise awareness about the energy and material impact that buildings produce in their life cycle is reinforced. And thus, contribute towards a view and appropriation of sustainability as a practice of the coherence.

-In relation to *design process and university training*, the importance of proposing training approaches that recover the virtues of the design activity in its cognitive constructions, linked to the logic of complex thinking and its contemporary contextualization, is highlighted. At this end, teaching contributions are needed in order to prioritize the construction of design thinking, which includes the analytical, creative and narrative (Rodríguez, 2022) through didactic strategies that incorporate the innovative, holistic, complex, modelling, collaborative and co-productive, multidisciplinary and transdisciplinary, the micro and macro view, reflection in action, case studies, problem cases and learning from others (Cravino, 2020c).

-In relation to *design and its categories of "conditions, means and availabilities"*, it is invited to recognize the virtues of the design process as an epistemological field, such as the way of thinking and the way in which architects relate to the world. Including the topics of technological-energy efficiency, climate change and the impact of the built environment in content programs is not enough. Its integration into design process cannot be done in an additive way, but rather in an integrated and systemic manner. In this sense, the limitation of approaching a complex process (such as the teaching of architectural design) from a determined set of variables is recognized. Even so, its explicitness is important to reflect on the personal actions (as student, teacher, professional) and incorporate unavoidable aspects for the current design. Therefore, we must recognize and work on the training of design thinking, in order to anticipate and co-create possible and desirable realities, in a complex logic that interrelates "know" (knowledge), with "know to do" (abilities, skills) and "know how to be" (positioning and values). Realities towards greater cultural coherence, technological-energy efficiency and environmental awareness.

6. REFERENCES

Ahmad, T; Zhang, D. (2020). A critical review of comparative global historical energy consumption and future demand: The story told so far. *Energy Reports*, 6, 1973–1991. https://doi.org/10.1016/J.EGYR.2020.07.020

Balances Energéticos Nacionales (2023). *Balance Energético Nacional Serie histórica – indicadores: Actualizado al año 2021*. Dirección de Información Energética, Subsecretaría de Planeamiento Energético, Secretaría de Energía, Argentina. Visto septiembre, 2023. https://www.argentina.gob.ar/econom%C3%ADa/energ%C3%ADa/planeamiento-energetico/balances-energeticos.

Barbaresi, A; Bovo, M.; Torreggiani, D. (2020). The dual influence of the envelope on the thermal performance of conditioned and unconditioned buildings. *Sustainable Cities and Society*, *61*. https://doi.org/10.1016/j.scs.2020.102298

Bellot, R.; Fiscarelli, D. (2021) "Vivienda contemporánea e instalaciones: entre la objetividad tecnológica y la subjetividad del proyecto arquitectónico". *ARQUITECNO*, 18 (1). Pp. 75-84. http://dx.doi.org/10.30972/arq.0185671

Blasco Lucas, I. (mayo-octubre 2022). Bases para un modelo del proceso creativo de la arquitectura sustentable. [Archivo PDF]. *AREA*, 28(2), pp. 1-16. Recuperado de https://www.area.fadu.uba.ar/ wp-content/uploads/AREA2802/2802_blasco-lucas.pdf

Blasco Lucas, I. (2013). *Arquitectura Sustentable en Hábitat Rural de Zona Árido-Sísmica: Aportes Teórico-Metodológicos*. Tesis Doctoral en Arquitectura. Mendoza: UM.

Cravino, A. (2020a) *Investigación y tesis en disciplinas proyectuales: Una orientación metodológica*. Ed. FADU-UBA. CABA: Diseño.

Cravino, A. (2020b) "Una reflexión histórica sobre las materias científicas, tecnológicas y técnicas en la carrera de Arquitectura". En Revista *PENSUM (6)*. Pp. 171-188.

Cravino, A. (2020c). Pensamiento Proyectual. *Cuadernos Del Centro De Estudios De Diseño Y Comunicación*, (94). https://doi.org/10.18682/cdc.vi94.3887

Dubberly, H. (2022) Why Should Stop Describing Design as "Problem Solving". https://www.dubberly.com/articles/why-we-should-stop-describing-design-as-problem-solving.html

Fernández, J, L.; Rodríguez, L. G. (2022-2026) "La dimensión tecnológico-energética en la enseñanza del saber proyectual. Análisis y propuesta para la formación de nuestros futuros arquitectos". Proyecto de Grupos de Investigación, DGyT UNS.

Fernández, J. L.; Rodríguez, L. G.; Fiscarelli, D. M. (2021). Análisis y propuesta de mejoramiento energético, económico y de habitabilidad en la edificación educativa pública de la UNS. *ARQUITECNO*, 18 (1). Pp. 15-24. http://dx.doi.org/10.30972/arq.0185666

Fernández, J. L.; Vecchi, R.; Rosello, B. (2019). *Taller de Arquitectura Sur*. Propuesta pedagógica/ académica, Carrera de Arquitectura, Departamento de Geografía y Turismo, Universidad Nacional del Sur. Bahía Blanca, Argentina.

Faludi, J.; Acaroglu, L.; Gardien, P.; Rapela, A.; Sumter, D.; Cooper, C. (2023) "Sustainability in the Future of Design Education". *She Ji: The Journal of Design, Economics, and Innovation, Volume 9, Issue 2*, 157-178. https://doi.org/10.1016/j.sheji.2023.04.004.

Fiscarelli, D.; Bellot, R. (2023) "La enseñanza de las asignaturas técnicas en arquitectura. El caso de las instalaciones, herencia academicista versus integración disciplinar". *Anales de Investigación en Arquitectura*, 13 (1). https://doi.org/10.18861/ania.2023.13.1.3421

Foqué, R. (2010). *Building Knowledge in Architecture*. Bruselas: University Press Antwerp.

Gelardi, D. y Esteves, A. (2004). "La dimensión ambiental de la arquitectura como eje organizador del procedimiento proyectual para una arquitectura sustentable". *AVERMA*, *8*(1), pp. 133-137.

Gelardi, D. y Esteves, A. (2002) "Transferencia de conocimientos en la investigación una experiencia didáctica de la arquitectura sustentable". *AVERMA*, 6(2). Pp. 10.49-54.

Lawson, B. (2002) *How designers think: the design process demystified*. 3th. edition. Oxford: Elsevier/Architectural.

LETI. (2020). *Climate Emergency Design Guide*. https://www.leti.uk/cedg

Ley de Educación Superior Nro. 24521 (1995). Diario Oficial de la Rep. Argentina. Buenos Aires, 1995.

Meirinhos, M., & Portela, L. de J. (2023). Education in liquid modernity: educate and forming in an uncertain world. *Revista Produção E Desenvolvimento*, 9(1), e621. https://doi.org/10.32358/rpd.2023.v9.621

Mesquita, L., & Ripper Kós, J. (2017). Towards more resilient and energy efficient social housing in Brazil. *Energy Procedia*, 121, 65-70. https://www.researchgate.net/publication/319951271_Towards_more_resilient_and_energy_efficient_ social_housing_in_Brazil

Noel, L.A.; Ruiz, A.; van Amstel, F.; Udoewa, V.; Verma, N.; Botchway, N. K.; Lodaya, A.; Agrawal, S. (2023) "Pluriversal Futures for Design Education". *She Ji: The Journal of Design, Economics, and Innovation, Volume 9, Issue 2*, 179-196. https://doi.org/10.1016/j.sheji.2023.04.002.

Rodríguez, L. G. (2023-2026) "Construcción de estrategias didácticas de evaluación a partir de la integración de las variables tecnológicas y energéticas de los edificios en el proceso proyectual". Beca Posdoctoral CONICET.

Rodríguez, L. G. (2023-2025) “Eficiencia energética y tecnológica en el proceso proyectual: Estrategias didácticas para su integración y evaluación”. Plan de actividades CIC CONICET.

Rodríguez, L. G. (2023) Acuerdos epistemológicos para el saber proyectual. AREA 29 (2). Pp. 1-9. https://area.fadu.uba.ar/area-2901/rodriguez2901/

Rodríguez, L. G. (2022). Nuestra didáctica para el saber proyectual. *Cuadernos Del Centro De Estudios De Diseño Y Comunicación*, (175). https://doi.org/10.18682/cdc.vi175.8605

Rodríguez, L. G. (2021) “Arquitectura ambientalmente consciente”. Propuesta pedagógica, asignatura optativa de formación complementaria, Carrera de Arquitectura UNS. Material inédito.

Rodríguez, L. G. (2020) *La evaluación formativa en Arquitectura. Aportes para la enseñanza desde la formación integral en los talleres FAU, UNLP*. Tesis doctoral FAU UNLP. La Plata: SEDICI Repositorio institucional de la UNLP. https://doi.org/10.35537/10915/127714

Rodríguez, L. G. (2017). “Eficiencia energética edilicia: aportes de evaluación, aplicación y reflexión desde la vivienda a la ciudad”. Primer premio categoría Difusión, en *Premio Bianual a la Investigación Patrocinada, CAPBA 2017*. Buenos Aires, Argentina.

Rodríguez, L. G. (2015). *Instrumentación metodológica para el reciclado masivo de la edilicia residencial orientada a la eficiencia energética*. Tesis doctoral. Doctorado en Ciencias, área Energías Renovables, FCE, UNSa.

Rodríguez, L. G.; Fernández, J. L. (2021) “Eficiencia energética y sustentabilidad como ejercicio de la coherencia: propuesta de investigación y docencia para el saber proyectual”. Actas de Congreso, XXIV Congreso ARQUISUR, 2021. FAU-UNT y FAU-UC, Tucumán y Santiago.

Rodríguez, L. G.; Fiscarelli, D. M.; Fernández, J. L. (2022) “La dimensión técnica en la enseñanza proyectual: entre la ciencia y el diseño”. *ARQUITECNO*, 19 (1). Pp. 53-62. http://dx.doi.org/10.30972/arq.0195969

Rodríguez, L. G.; Fiscarelli, D. M. (2021). *Teoría y praxis de la arquitectura contemporánea. Aportes en investigación y docencia desde el saber proyectual*. San Lorenzo: FADA, UNA.

Rodríguez, L. G.; Martini, I.; Discoli, C. (2017) *Criterios y métodos para el reciclado edilicio con eficiencia energética*. La Plata: Arte editorial Servicop.

Rodríguez, L. G.; Martini, I.; Discoli, C. (2016) Energy storage for residential dwellings. Methodology to improve energy efficiency and habitability. *Journal of Energy Storage* (8). Pp. 99-110. https://doi.org/10.1016/j.est.2016.09.009

San Juan, G. A.; Viegas, G. M.; Reynoso, L. E.; & Belén Esparza, J. (2023). The popular habitat. Systemic model to approach a housing solution proposal and its urban insertion. *Revista de Arquitectura* (Bogotá), 25(1), 25-39. https://doi.org/10.14718/RevArq.2023.25.4132

San Juan, G. (2013). *Diseño bioclimático como aporte al proyecto arquitectónico*. La Plata: UNLP

Sarquis, J. (2007). *Itinerarios del Proyecto. La Investigación Proyectual como forma de conocimiento en arquitectura)*. Buenos Aires: Nobuko. Volume 1.

Subramanian, S., Bastian, H., Hoffmeister, A., Jennings, B., Tolentino, C., Vaidyanathan, S., and Nadel, S. (2022). *2022 International Energy Efficiency Scorecard*. www.aceee.org/research-report/i2201

Watkins, M.; Casamayor, J. L.; Ramirez, M.; Moreno, M.; Faludi, J.; Pigosso. D. (2021). “Sustainable Product Design Education: Current Practice.” *She Ji: The Journal of Design, Economics, and Innovation 7, no. 4*, 611–37. https://doi.org/10.1016/j.sheji.2021.11.003.

Zeisel, J. (1984). *Inquiry by Design*. Cambridge: Cambridge University Press

DECLARATION OF CONTRIBUTIONS TO THE ARTICLE

ROLE	Author1	Author2
Conceptualization – Ideas; formulation or evolution of overarching research goals and aims.	X	X
Data curation – Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.	X	
Formal analysis – Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data.	X	
Funding acquisition - Acquisition of the financial support for the project leading to this publication.	X	X
Investigation – Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.	X	
Methodology – Development or design of methodology; creation of models.	X	X
Project administration – Management and coordination responsibility for the research activity planning and execution.	X	X
Resources – Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.	X	X
Software – Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.	-	-
Supervision – Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.	X	X
Validation – Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.	X	X
Visualization – Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.	X	
Writing – original draft – Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).	X	
Writing – review & editing – Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.	X	X