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Article

The Systematisation of Survey Drawings: Identifying the Development of Morphological Awareness via Teaching Approaches

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Abstract: The graphic replication of architectural examples has long been a prevalent pedagogical method, regardless of educational orientation. The critical reactivity of the mid-20th century, reinforced by ethnographic and anthropological tools, positioned vernacular architecture as a key educational resource—a process widely recognised and extensively studied in Portugal. This article examines the role of fieldwork and surveying techniques in architectural education, extending beyond geometric characterisation to encompass the recognition of technological principles and logics. Through the systematic application of decomposition/composition drawing exercises with first-year students over a decade, this study explores how structured graphical methodologies foster a deeper understanding of buildings, beyond their aesthetics. The findings indicate that perception skills constitute a crucial competence in architectural teaching curricula. The systematisation of hand drawing surveys, applying layering superimposing, is a valuable method to enhance these capacities practically. The results reinforce that early engagement with analytical drawing improves students' ability to integrate conceptual and technical aspects in design, supporting a progressive transition to digital tools. Additionally, the results highlight the pedagogical value of vernacular studies in promoting adaptive and sustainable design thinking, reinforcing the need for a balanced approach that synthesises traditional and contemporary methodologies in architectural education.

Keywords: graphic representation; drawing; architectural education; vernacular architecture; architectural survey; built heritage documentation

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1. Introduction

The relationship between representation and the real object, particularly in architectural practice, is intrinsically tied to the cultural context [1]. The reciprocity between drawing reproduction and design creation raises critical questions about the systematisation of its pedagogical principles [2] and its role in fostering critical thinking beyond technical proficiency [3]. Figurative graphic reproduction of reference models has historically been, and often remains, a key pedagogical tool in architectural education [4].

Rooted in fine arts traditions, architectural education has long balanced a lack of scientific autonomy and its inevitable technological specificity [5]. In Portugal, the classical model prevailed until the decade following the 1957 higher education reform, legitimising architecture through a historical and compositional framework [6] (p. 134). This technical foundation, alongside its coexistence with the visual arts, fostered a focus on mimetic virtuosity over expressive subjectivity, which was more valued in other disciplines. A strong emphasis on mastering descriptive geometry also emerged, possibly as a deliberate distinction from the exact sciences. Consequently, architectural drawing prioritised geometric precision and linear representation—paradoxically abstract yet intuitive in conveying volume [7]. It was used as a tool for reproducing and communicating reality with a fragmented figurative dimension, visually assertive yet reductive in broader architectural and anthropological aspects [8] (p. 73). A notable example was the widespread practice of replicating classical orders, commonly taught within architectural composition across major Western schools [9] (p. 161).

Following the neo-realist movement in Southern Europe during the early 20th century, the Survey of Portuguese Regional Architecture led to the gradual replacement of model drawing with survey drawing in Portugal [10]. Integrating anthropological and ethnographic methods, this shift encouraged a more analytical and less figurative approach, prioritising morpho-typological records of cultural interpretation (Figure 1). This had a recognised impact on contemporary Portuguese architecture [11].

Figure 1. The Survey of Portuguese Regional Architecture constituted a milestone in the Portuguese architecture circle. Image of the survey of a communal threshing floor. Personal archive of António Menéres, 1956, kindly provided to the authors.

The primary focus of this study is the systematic application of observational drawing to enhance visual thinking as a fundamental skill within contemporary architectural curricula. Most European study programmes do not establish a formal connection with this subject [12]. Our perspective contrasts with the pressure exerted by educational, commercial, administrative, and funding entities to prioritise digital transition, often marginalising analogue approaches—an effect evident in post-curricular updates [13].

Despite the extensive body of research on architectural education, most studies emphasise the dichotomy between analogue and digital methods rather than their potential complementarity [14]. This article aims to demonstrate that the development of perceptual skills [15] is essential to architectural training, fostering a critical and integrated use of digital tools while enhancing technical processing and conceptual depth [16]. Furthermore, the diversity of entry requirements for higher education has led to a decline in students' perceptual and interpretative abilities concerning architectural phenomena—previously shaped by strong foundations in descriptive geometry and figurative drawing [17].

Although recent research highlights the importance of visual thinking strategies in undergraduate education, most of the existing literature does not engage with architectural education, representing a significant gap in the field [18,19].

2. Theoretical Framework

This research fosters the critical role of foundational learning experiences in shaping students' conceptual and technical competencies during the early stages of architectural design education. Most of the available studies use mostly qualitative analysis, based on empirical human receptibility, aiming to demonstrate that structured exercises integrating technical and conceptual learning lead to higher design performance [20]. This reinforces the need for a methodical teaching progression, where early technical grounding enhances future design capabilities. Relevant references stress the importance of incorporating historical and traditional knowledge into architectural education to foster contextually relevant design [21]; however, most of the available literature is based on very limited experiences and vague extrapolation of results. This study supports the stated premise by demonstrating how graphical decomposition exercises, rooted in vernacular principles [22], promote critical thinking and a deeper understanding of materiality. Students report that these exercises help bridge traditional construction insights with actual architectural challenges, validating the integration of historical evidence as a strategy for developing sustainable and adaptive designs. Moreover, it debates the integration of technology in design studio teaching, advocating for a balanced approach between traditional methods and digital tools [23]. This study corroborates the perspective in architectural teaching that a gradual transition from manual techniques to digital tools like BIM systems leads to better educational outcomes. Students who first develop a strong technical and conceptual foundation through analogue exercises tend to excel when later adopting digital technologies [24]. This phased approach ensures mastery of both tools and design principles, enabling the synthesis of complex solutions. This research underscores a structured approach to architectural representation, beginning with fundamental construction components and progressing through layered visual perceptions. This aligns with Christopher Alexander's famous concepts, where design emerges through interconnected "patterns" that are universal yet adaptable [25]. Alexander's emphasis on the interplay between form and function parallels this study's focus on integrating technical systems with formal design processes. His advocacy for context-sensitive design also resonates with the immersive fieldwork experiences described in this study, reinforcing a pedagogical model that links design representation with construction, culture, and environment [26]. Moreover, this study draws on the perspective that vernacular models in architectural education should focus on underlying principles rather than replication [27]. The documentation process becomes a critical tool, enabling students to propose solutions based on current needs while systematising construction knowledge rooted in local building cultures [28]. By integrating these principles into architectural curricula, as advocated by various scholars, students develop a richer understanding of traditional construction methods in connection with contemporary technologies [29]. Within an academic context, this study also considers the impact of the European standardisation of higher education under the

Bologna Process, implemented from 2009 onwards. The transition from a predominantly practice-based model, established over a century, to one incorporating mandatory scientific research has significantly altered the student profile [30]. This shift is particularly evident in the introduction of the master's thesis, explicitly steering education towards theoretical reflection. How, then, should technical knowledge and the fundamental principles of architecture and design be implemented? These elements must adapt to social and technological evolution, aligning with contemporary cultural realities and the profession's changing demands. This is particularly relevant within a heterogeneous European context, where the architectural profession fluctuates between affirmation and uncertainty [31]. Despite the references cited being central to the methodological premises in architectural design, they tend to remain within the realm of the visual arts, thus avoiding a more multidisciplinary approach and broader scientific validation [32]. This may be explained by the European academic tradition that has dominated the Western paradigm of architectural education, which establishes rigid boundaries for its references and, inevitably, its perspectives [33]. In contrast, fields traditionally more focused on research and development have invested in the implications of visual expression, with drawing at the forefront, as a means to enhance the development of their disciplines, advocating for its systematic integration into higher education [34]. One of the most prominent examples is the increasing number of studies in medicine, particularly in surgical fields, that focus on the potential of applying visual thinking strategies within their academic curricula [35]. It is important to note that much of the work carried out in this field remains overlooked in current curriculum programmes, and much of the literature supporting design units still relies on references that lack technical and scientific rigor [36].

3. Materials and Methods

This study employed a qualitative longitudinal research approach to examine the impact of structured learning experiences on architectural education over a ten-year period (Figure 2). Data collection followed a sequential, participatory, and recursive process, ensuring both reliability and depth of analysis [37]. Data were gathered from multiple cohorts of students (characterised in the next chapter) enrolled in an architecture and urbanism program, maintaining consistency in curriculum structure and teaching staff. The following methods for data collection were employed:

(a) Document Analysis—A systematic review of design studio exercises across all nine semesters of the undergraduate curriculum. At the end of each semester, final design studio presentations were collected, with the most relevant materials archived as didactic resources for future cohorts. Most of the images presented in this paper originate from the institutional digital archive, established in 2012.

(b) Semi-structured Interviews—Conducted with final-year undergraduate students to assess their learning trajectories. Third-year (1st cycle) and fifth-year (2nd cycle) students participated in semesterly Coordination Group meetings, where class representatives provided feedback on content comprehension, technical skills, tool implementation, methodological assimilation, and critical development. Students were encouraged to reflect on both their achievements and challenges. Additionally, they completed a mandatory digital survey evaluating each course unit and instructor as part of an internal quality assessment process.

(c) Academic Records' Examination—A comparative analysis of design studio final evaluations and overall academic performance. This analysis was facilitated by access to the institutional record platform (SIGE management system), which enabled the tracking of individual student progress and the identification of correlations between semester performance and long-term academic outcomes. Although individual records remained confidential, general performance trends were reflected in the annual Coordination Report, which is publicly accessible for ministerial review.

(d) Graduate Interviews—Semi-structured discussions with master's students prior to thesis development. These interviews followed the same structure as (b) but encouraged a more critical perspective, including reflections on professional expectations.

(e) Thesis Analysis—Examination of master's theses focused on technical architectural development, assessing students' ability to integrate conceptual, technical, and representational skills.

		Integrated Master of architecture and urbanism (Bologna process)					
		general development			specific development		
		1º CICLE			2º CICLE		
Degree Year		1st Year	2nd Year	3rd Year	4th Year	5th Year	Vernacular survey site:
Implementation	2012-2017	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	mountain water mills (Gávea, Portugal)
1st students group	2013-2018	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	mountain water mills (Montaria, Portugal)
2nd students group	2014-2019	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	mountain water mills (Rosal, Spain)
3rd students group	2015-2020	2015/2016	2016/2017	2017/2018	2018/2019	**2019/2020**	maize granaries (Porreiras, Portugal)
4th students group	2016/2021	2016/2017	2017/2018	2018/2019	**2019/2020**	2020/2021	mountain water mills (Rosal, Spain)
5th students group	2017/2022	2017/2018	2018/2019	**2019/2020**	2020/2021	2021/2022	mountain water mills (Rosal, Spain)
6th students group	2018/2023	2018/2019	**2019/2020**	2020/2021	2021/2022	2022/2023	maize granaries (Porreiras, Portugal)
7th students group	2019/2024	**2019/2020**	2020/2021	2021/2022	2022/2023	2023/2024	mountain water mills (Gávea, Portugal)
		2020/2021 (change of paradigm)					
		2021/2022 (study cycle revision)					
		2022/2023 (revised study cycle)					
		Survey exercise			1st set of Interviews		2nd set of Interviews

Figure 2. Sampling contextualisation diagram, for the academic years considered in the present study.

Qualitative data were systematically processed, based on interpretivist perspectives [38], using the following:

- Thematic analysis, identifying recurring patterns in student reflections and academic performance, with particular attention to high-achieving students (scores above 16/20, classified as "Good" or higher).
- Categorisation of interview responses, correlating student feedback with key learning outcomes, with selected excerpts transcribed in this paper.
- Triangulation of findings, cross-validating insights from design exercises, interviews, and academic records to enhance reliability.
- Longitudinal comparison, tracking the evolution of specific competencies over time and assessing the retention or dilution of skills. This included evaluating individual performance, autonomy, and critical thinking development, supplemented by faculty feedback from regular school meetings during semester planning and evaluations.

Additionally, where relevant, quantitative indicators—such as grade distributions, performance trends, and the number of technical outputs—were incorporated to complement qualitative insights. This methodological framework provides a structured and integrative approach to assessing the long-term impact [39] of architectural education, ensuring a balanced evaluation of technical proficiency, conceptual understanding, and representational skills.

3.1. Sampling Definition and Study Context

This article is based on the study of the implementation of graphic survey exercises over a period of 10 years, during the first semester of an integrated master's degree in architecture and urbanism (developed within the 'Project Analysis' design studio unit, the core curricular unit of the first semester of the Integrated Master's Programme in Architecture and Urbanism at Universidade Portucalense (formerly Escola Superior Gallaecia)) in Portugal [40].

The scope and feasibility of this methodology were influenced by the relatively small scale of the architecture program, which had an average annual total enrolment of approximately 100 students during the study period. With class sizes of fewer than 20 students per semester, this occasionally allowed for a complete overlap between the study sample and the total student population in specific cases.

The sampling encompassed 72 students, enrolled in seven sequential classes of 1st-year students (from 2013 to 2019), who completed the educational programme (until 2023–2024). Around 50% of these students were working students, and the majority (70%) had prior knowledge in the fields of architecture and construction, particularly in technical drawing. This combination of students with diverse backgrounds implies a particular pedagogical dynamic, which must be considered in the present reflection, especially when compared to international standards.

The students had a broad profile with a gender balance. Students entering from secondary education had an average age of around 18 years. As a private educational institution, the average entry grades were medium to low.

The working student cohort, predominantly male (75%), showed a wider age range, varying between 25 and 45, with occasional exceptions. Until 2019, there was a significant intake of students with prior academic qualifications, particularly in technical architecture (construction management) and industrial engineering, mainly from Spain.

Compared to other architecture schools, there was a greater aptitude and willingness among these groups for technical operational matters. Conversely, they demonstrated a weaker preparation of theoretical subjects, with notable gaps in historical knowledge, a limited reading habit, and some resistance to critical conceptual development.

The number of students per session inevitably affected the quality of programmatic development and the capacity for revision of the students' work. Moreover, these conditions raised other issues concerning the students' performance, such as a lack of technical autonomy or a passive approach to critically interpreting the briefs, as observed throughout the course. These were, of course, circumstances inherent to the pedagogical project and the institutional identity that framed this study. They had, however, the advantage of stabilising the teaching staff in this unit over the decade in question (both authors of this article have been responsible for the curricular unit Project Analysis, a core subject in the first year of the program, without interruption, from 2012 to the present), allowing for a deeper reflection on the pedagogical strategy applied.

3.2. The Survey Object

This paper considers drawing as a privileged resource for developing perceptual skills and enhancing thinking and problem-solving [33]. It views drawing as an active, consciously engaged practice, in contrast to predominantly passive mental processes overshadowed by technical craftsmanship [41]. The focus is on strengthening perceptual learning through a systematic approach to the abstract representation of architectural phenomena. In this study, vernacular architecture is considered a suitable vehicle for this purpose, as it is inherently stripped of supplementary variables, driven by a cause-and-effect pragmatism that reveals the objectivity of the solution and the underlying need that generated it [42]. In alignment with the institutional identity, a vernacular architectural building was selected as the object of study, with the analytical scope extended to include the territorial context in its physical and cultural dimensions (Figure 3). Methodologically, the exercise, once limited to the normative domain of technical drawing based on the direct reading of a pre-existing structure, shifted focus towards identifying the connection between formal characteristics and their fundamental constraints (Figure 4). The objective was to represent the object through an understanding of its programmatic and technological logic, rather than relying solely on a superficial visual interpretation, both in terms of appearance and essence.

The choice of the vernacular building stems from the pragmatism inherent in the traditional constructive culture—specifically in northern Portugal—and the long-standing development of solutions within rural contexts [43]. Vernacular architecture is understood as a cultural expression, integrated into the shaping of the landscape, arising from the continuous adaptation of a given population to the factors of a specific region [44].

Figure 3. First-year students collecting data at the survey site, 2016. The first weeks are dedicated to fieldwork. Water mills of Picón y Follón, Spain.

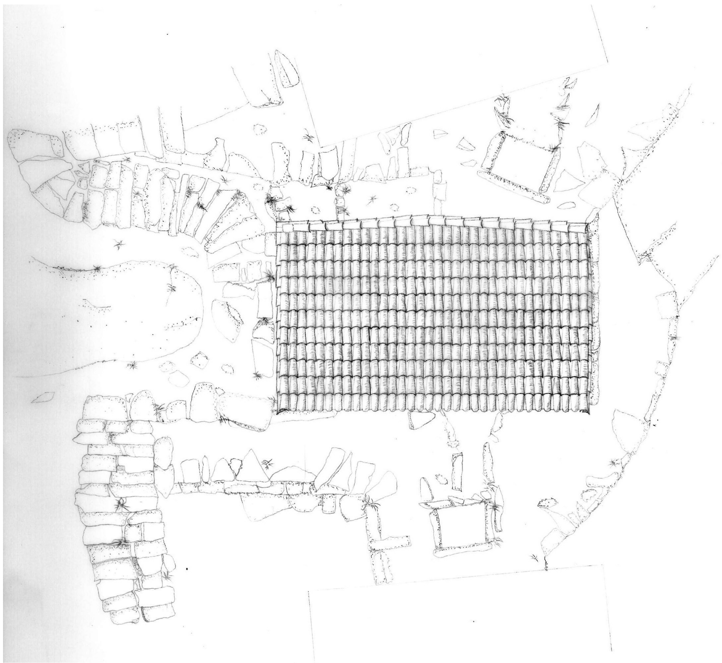

Figure 4. *Cont.*

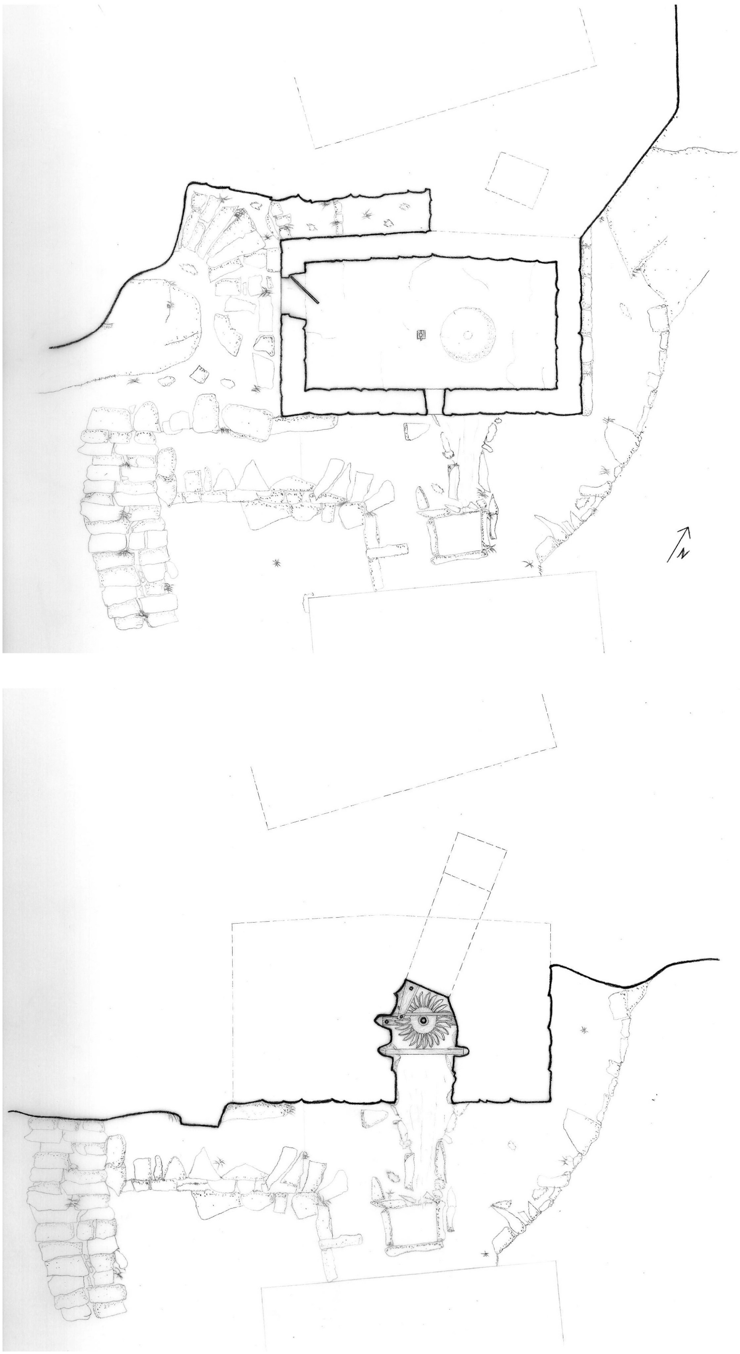

Figure 4. Sequence of plans, developed by transparent representation overlap. Juvenal Covas, 2015. 1:50. Picón y Follón, Spain.

This type of architecture represents the synthesis of programmatic accommodation and the optimised management of available resources, both material and human. The resulting solutions typically do not prioritise composition as an end in itself but rather see it as a consequence of the process of application and development [45] (pp. 4–16).

3.3. The Architectural Survey Method

The project course in the first semester adopted a survey as a foundational exercise, structured between fieldwork and studio development.

Procedurally, the graphic record was based on ICOMOS CIAV built heritage survey workshops, developed systematically since 2010 [46]. A stratified orthogonal projection was defined, consisting of four distinct stages, developed sequentially: matrix, configuration, texture, and shading [47] (Figure 5). The number of views depends on the geometric complexity of each building, hierarchically composed of plans, sections, and elevations (In this specific exercise, transparent paper was the chosen support material, after the initial extract. This approach allows students to understand and establish precise correspondence between different layers of information while ensuring geometric coherence across the various views. However, this solution significantly affects the digitalisation of the drawings, making it impossible to fully replicate the visual superimposition effect and the graphic quality of the original pieces, which has a negative impact on the images presented in this article).

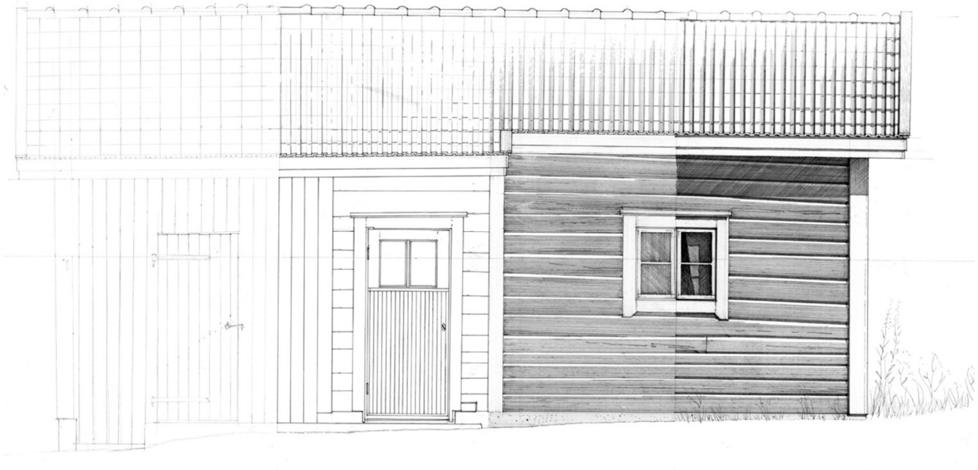

Figure 5. Demonstration of the 4 stages sequence, according to Markku Mattila, used for Vernadoc ICOMOS workshops. Reproduced from ref. [46].

The site plan, representing the territorial context, refers to a separate stratified order, as it corresponds to the representation of differentiated phenomena based on cartographic elements. However, it follows a similar logic of complementary and progressive layering. Although it constitutes the first stage of the study, it should be completed at the end of the exercise, allowing the student to have a more comprehensive understanding of the area after significant fieldwork.

4. Application and Development

4.1. Matrix

The matrix is the first and least figurative stage of the entire process. It involves identifying all the constructive components and their spatial relationships. Each component corresponds to a set of circumscribing lines that determine its connections with the others. These lines are then supplemented with boundaries, axes, arcs, or alignment angles.

It is important to note that, as this is the first year of study, the acquisition of both generic and specific construction vocabulary also contributes to the students' technical training. The systematic determination of the position, dimensions, and articulation of basic components (such as foundations, plinths, thresholds, lintels, quoin stones, courses, sills, voussoirs, uprights, partitions, main beams, wall plates, trusses, ridge beams, eaves, and other such structural elements) requires not only their general identification but also an understanding of their structural and formative roles in shaping the building model.

The matrix establishes a two-dimensional grid that combines written and numerical annotations with parameters of geometric configuration. These parameters allow students to grasp the fundamentals of each component, intuitively applying material characteristics and general principles of construction technology.

The students' lack of experience becomes evident in the density of the grid and the significance of their annotations (Figure 6). This is particularly clear when comparing the work of students with greater experience in the field. The matrix layer produced by the latter group tends to be significantly more concise, resulting in a less dense and visually cleaner grid. However, this may come at the cost of notable omissions, which can lead to a more superficial final outcome. The speed of the process for these more experienced students compensates for these gaps in comparison to their less experienced peers.

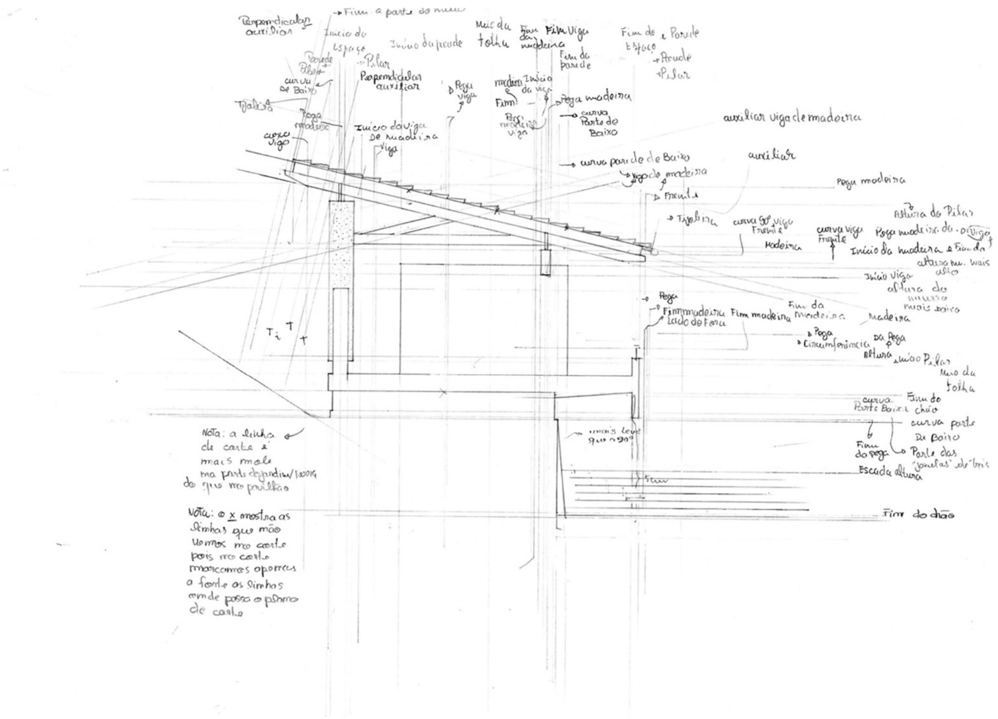

Figure 6. Example of a matrix layer, identifying most of the building components, in the 1st stage of the drawing process. Student Hugo Sambo, 2022. Tennis Pavilion at Quinta da Conceição, Portugal.

4.2. Configuration

The second layer corresponds to the geometric definition of each architectural component, drawn on a transparent layer over the matrix.

Regardless of the view, the process involves sequentially tracing the cutting lines, foreground views, middle planes, background planes, and potentially the most relevant projections. After emphasising the overall volumetry by defining the outlines based on the previous grid, the standard and unique compositional elements are then delineated. Standard elements must adhere to the rules and alignments defined in the matrix, allowing for less geometric precision compared to singular elements. For example, maintaining the alignment of the horizontal rows of ordinary masonry, based on the dimensions of the cornerstones, is more important than tracing the precise shape of each individual stone. The systematic repetition of any regular or irregular masonry pattern relies on principles of alignment, geometric stylisation, and average dimensions. Once these principles are established, the representation process becomes fluid and unencumbered (Figure 7). This approach efficiently addresses complex, irregular, and dynamic geometries, leveraging the manual gesture to speed up the drawing process while, when properly controlled, enhancing its plastic expression.

Singular elements, recognised as exceptions to the structural rules, should be approached with particular sensitivity. These elements should be few and as geometrically precise as possible. While they are not crucial for the conception of the generic model, they are essential for the external validation of the object being represented, ensuring the accuracy of the documentation. These details consolidate the perception of the object's identity, contributing to the technical realism of the morpho-typological model in which they are situated.

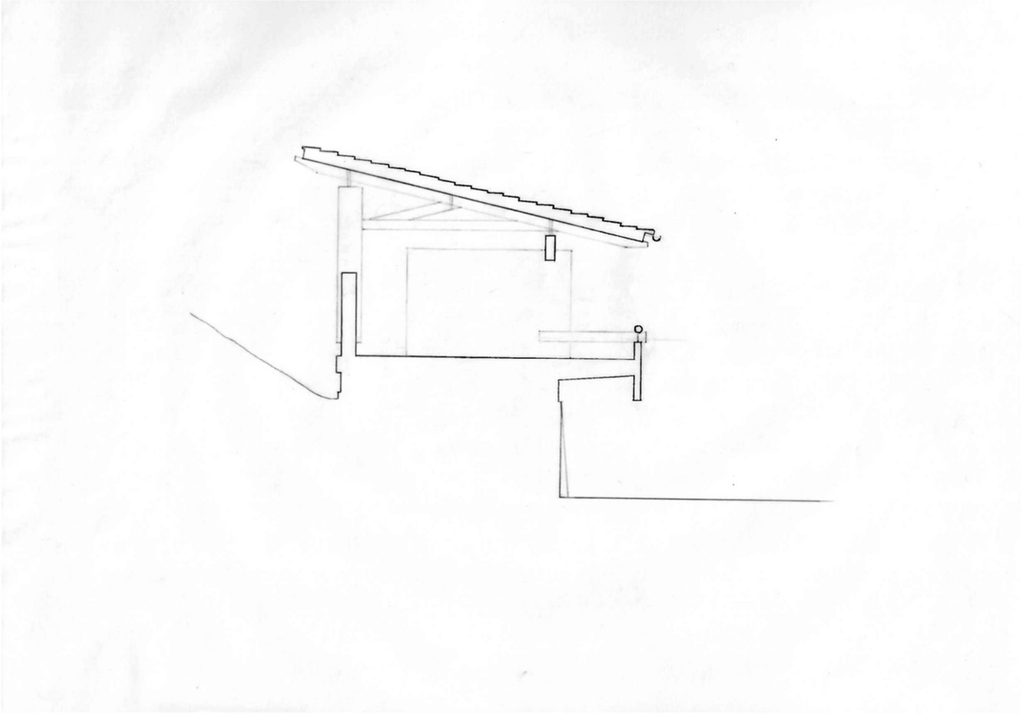

Figure 7. Detachment of the configurational layer, in the 2nd step of the drawing process. Hugo Sambo, 2022. Tennis Pavilion at Quinta da Conceição, Portugal.

4.3. Texture

The texture layer corresponds to the synthetic representation of the materiality of the identified components, applied as a surface fill on a transparent layer over the configuration (Unlike the typical approach of computer-aided drafting, only visible elements are represented in the drawings, with sectioned components indicated solely by line thickness and hollow interiors. This choice is justified by the inherently time-consuming and meticulous nature of manual drafting, which does not permit error correction without significantly impacting the final record.).

Despite the realistic expression it offers, it is a technical and abstract action that requires systematic execution and discipline. This step involves identifying the material associated with each visible element and assigning it a specific graphic typology. For each material, a pattern is selected that allows for quick and comfortable execution. Subsequently, each pattern is adjusted based on the appropriate intensity and density, according to its fidelity to the actual object. Unlike the strict graphic conformity required in previous phases, this execution depends primarily on two key factors: the author's sensitivity and the time available. These conditions allow for the development of each process's graphic identity, though they should not result in expressive differentiation between each drawing. The potential of this phase often leads students to overestimate its hierarchical importance, sometimes reversing the order of the layers or exaggerating the application of textures. This is counterproductive, as it compromises the overall precision by neglecting geometric boundaries and creating diluted configurations, or it demands excessive effort, which eventually diminishes the necessary graphic contrast for distinguishing between elements.

The nature of vernacular buildings, rooted in traditional construction systems, significantly reduces the range of textures applied, while allowing for greater variation. The irregularity of their stereotomy enables the manual process to benefit from organic representation. Smooth or polished materials are treated as empty surfaces, only textured in areas showing imperfections, pathologies, or where joints are suggested. Notably, their representation is preferably achieved through hatching, with solid fills reserved for specific situations like the characterisation of water planes.

Renders are depicted with fine dots, whose density and clustering depend on their original roughness and the attention given by the author, requiring a mutual compromise. Stone textures, depending on their porosity, are composed of systematic clusters of medium-sized dots and small lines, formalised in regular directions according to their geological conditions. Typically, for efficiency, texture densification occurs along the edges opposite the light source, enhancing the volumetric quality of each element (Figure 8).

Wood textures are generally formed in a multi-layered system, beginning with irregularly interrupted medium-thickness lines spaced randomly. A second layer follows with finer lines, spaced more regularly and closely together. Concentric ellipses are then added to represent knots, placed in the most evident spaces. An optional final layer may be applied to unify the surface and soften the representation of knots. All lines, including the placement of ellipses, should follow the grain of the wood.

As with geometric configuration, imperfections should be simplified proportionally. Metal elements are typically represented by closely spaced fine lines, drawn in the longitudinal direction of the element, with clusters of dots in oxidised areas.

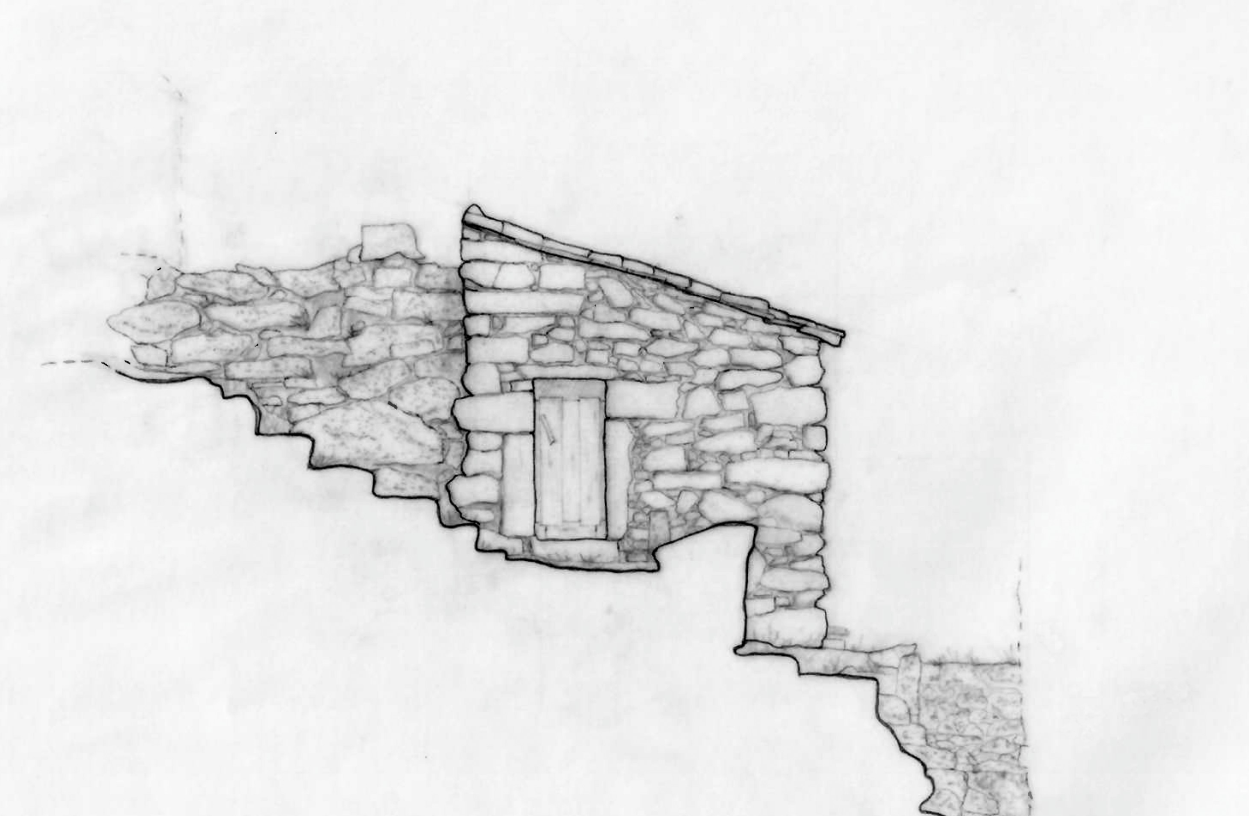

Figure 8. *Cont.*

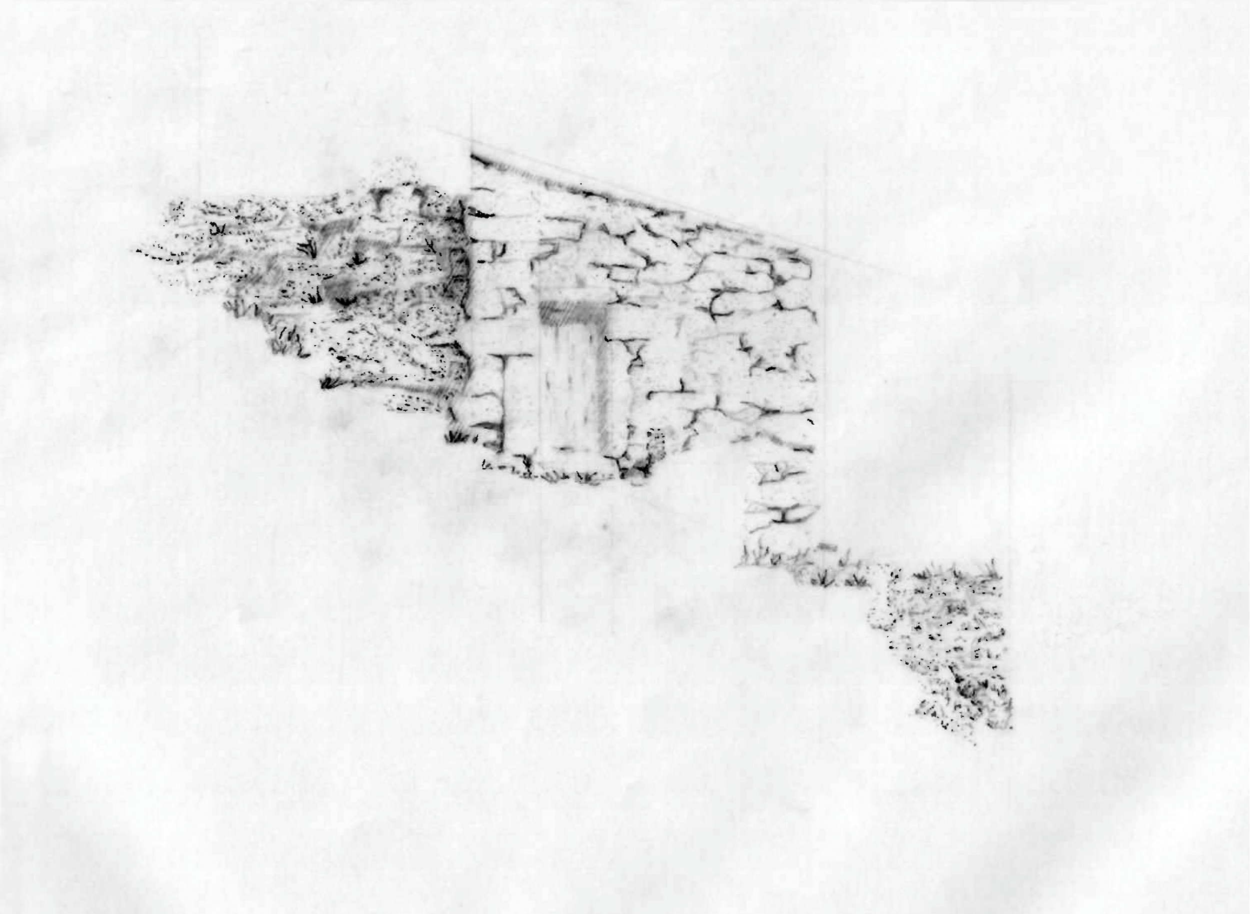

Figure 8. Detachment of the texture layer, identifying material differences between building components. Olalla Rivero, 2017. Picón y Follón, Spain.

Figure 9. Workshop tutor's drawing. The practical demonstration is fundamental it the early stage of the survey. Shivapakwajjanalert, 2019. Paredes de Coura, Portugal.

The ground surface in the immediate surroundings is rendered with dots for sandy terrain or small radially converging line segments, with densification reflecting existing topographic breaks and expressed in the direction of the slope.

The execution of each hatch pattern and its intensity should be tested before final application to ensure efficient completion. For more intense hatches, it is advisable to use masks for boundary definition, ensuring uniformity and speed. In this stage of the process, the author's research and experience are critical for the development of the documentation, as this phase is the most autonomous and graphically distinct. In some cases, the exercise was complemented by a series of intensive workshops in collaboration with more experienced faculty, sometimes involving international activities, as shown in Figure 9 [48] (pp. 188–190). In all such cases, there was a significant improvement in the speed of the exercise's execution. Before finalising the drawing, fragmented texture tests were introduced, supported by specific literature, considering graphic examples of the most common material typologies.

4.4. Shading

The final layer involves the introduction of shadows on the overlaid elements. Similar to the texture phase, despite its expressiveness, shading requires a technical and systematic approach. Of all the strata, shading is the most rigid in terms of execution. While texture adds a layer, shading functions more like a glaze, both as a technique and as a final product. Therefore, it must be applied at the end of the process. Despite this being a straightforward rule, students often exhibit a tendency to subvert it! Shading involves the direct application of shadow theory in an orthogonal projection system. The purpose of representing both cast and self-shadows is to emphasise the depth between objects at different distances by highlighting the figure–ground relationship between elements (Figure 10).

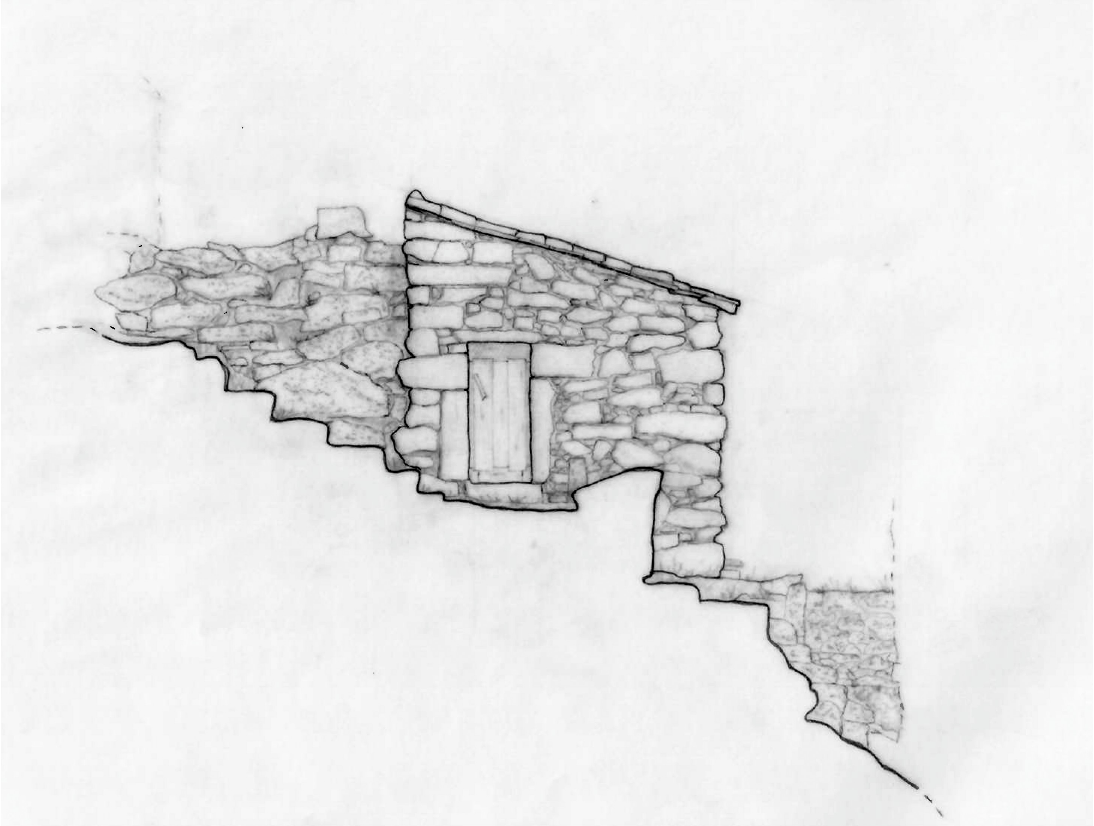

Figure 10. *Cont.*

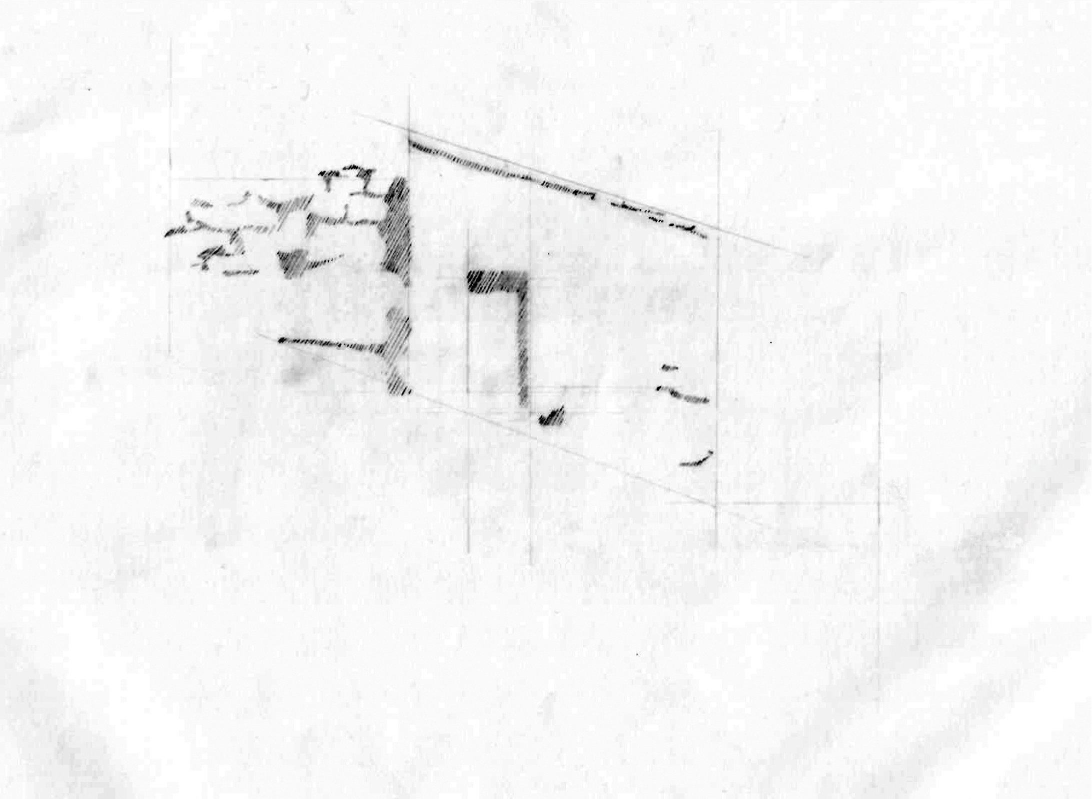

Figure 10. Detachment of the shadow layer, enhancing the volume and the articulation between structural elements. Olalla Rivero, 2017. Picón y Follón, Spain.

The light source is represented by parallel vectors at a 45-degree angle, descending from top to bottom, front to back, and left to right. However, sensitivity is required to adapt the direction of light according to the specific configuration of the building, especially concerning the positioning of existing openings. This adjustment creates an atmospheric effect within the interior space, interpreted according to the entry of natural light. It is essential to remind both students and some instructors that this lighting indication does not reflect a study of solar incidence. Any connection with actual solar exposure is as irrelevant as it is inconsequential to the graphical representation.

The vectors filling the shadowed areas are represented in absolute black, drawn as thin and closely spaced lines, creating a uniform and precisely defined glaze effect.

5. Pedagogical Context

The exercises were conducted between 2012 and 2022 in a rural context, focusing on heritage clusters of vernacular buildings, such as communal granaries and water mill nuclei [48] (pp. 188–221). Geographically, for logistical reasons, the study area was established in the western quadrant of the Minho River basin.

This approach considers that vernacular architecture lends itself to a particular morphological understanding, with high pedagogical potential. According to various authors, this perspective lies in the synthesis that this type of architecture achieves between technological pragmatism and programmatic necessity [49] (pp. 17–22). The awareness of resource management, including material, human, and energy resources, becomes essential and complementary in the survey process. Establishing relationships with the techniques and procedures associated with construction becomes inevitable and often anticipates graphic solutions. In a way, the justification for each architectural element is intuited, and, consequently, so is its representation. Anthropological immersion is crucial at the initial stage of the exercise [50]. Every year, through lectures and interviews, students are exposed to the local constructive culture and the remnants of the corresponding subsistence economy (these exercises were usual complemented by additional activities developed within the Project Analysis scope and other first-semester curricular units, such as Morphology and Anthropology of Space or Materials and Construction Analysis).

The first significant objective in developing the graphic characterisation work is the integration of all the field notes made on these aspects into the geometric systematisation grid, the matrix. Rather than being a purely descriptive exercise in geometric capability, this task requires the application of a fundamentally constructive understanding. This approach encourages the development of drawing aligned with the actual construction process, focusing on the sequential marking of the alignments of basic structural components (these notes pertain to systems such as foundations, plinths, floors, walls or columns, roofs, cladding, finishes, and openings). The crossing of graphic information with field notes creates a retroactive correction process in the matrix, revealing the student's ability to articulate the identified relationships and their systematisation. In the best-performing survey exercises, it was observed that the matrix layer played a crucial role in the overall development and congruence of the process.

The texturing phase requires a technical assessment dependent on research and testing. Its execution should be smooth and agile, using drawing as a tool for synthesis and discernment, aiming to enhance efficiency through expression. The application of shading glaze confirms the student's mastery of descriptive geometry, particularly in shadow theory. Understanding the three-dimensional configuration of the object, once sectioned, is verified through the introduction of projected shadow areas and the graphic reinforcement of planes in self-shadow. In terms of pedagogical objectives, shading is an expressive complement with relative importance compared to the quality of the previous strata [47]. In order to create representation dynamics and to exemplify similar process interpretation, complementary exercises are developed on prosaic objects, such as those provided in Figure 11.

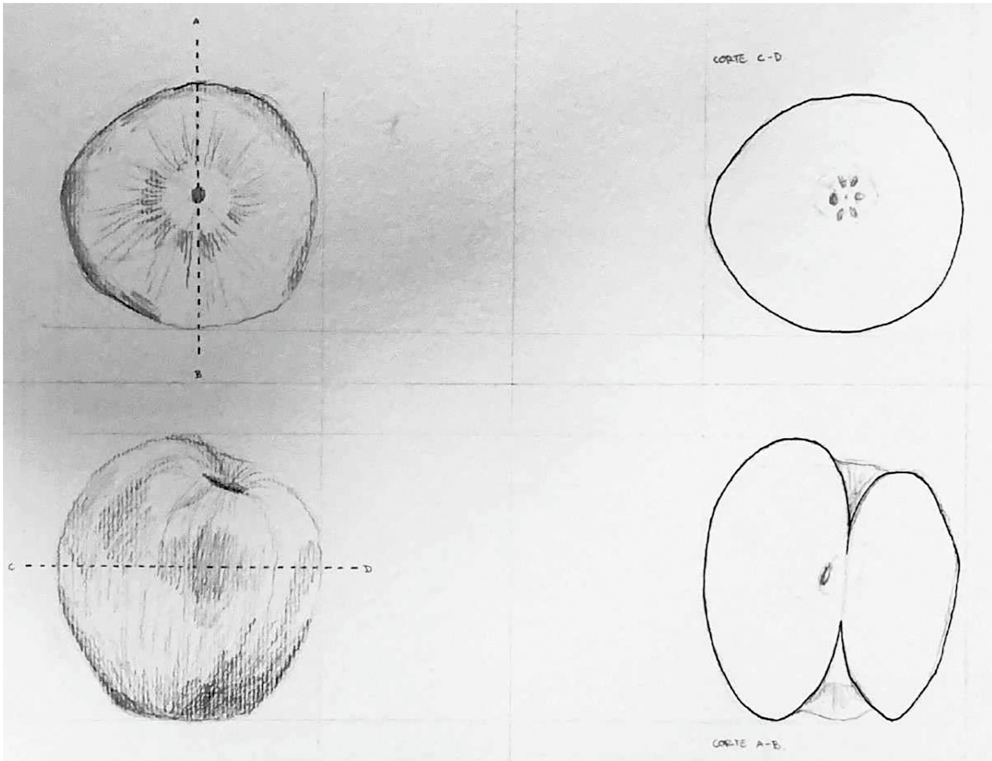

Figure 11. *Cont.*

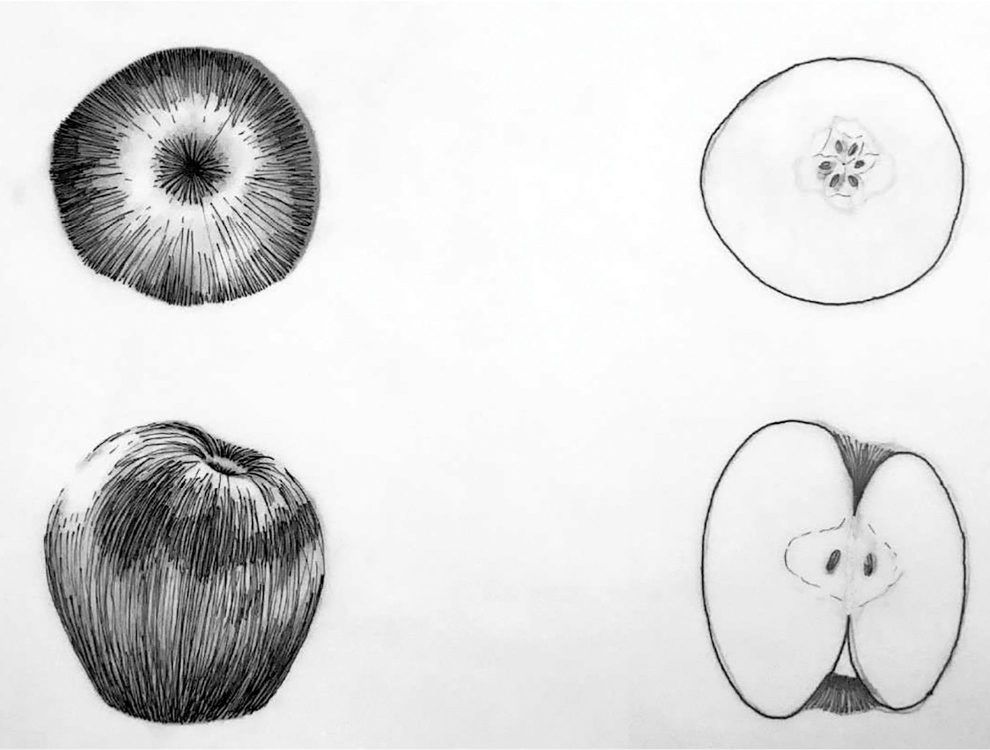

Figure 11. Extrapolation of the survey method via quicker and simpler draw exercises. Drawing an apple. Irene Blomeyer, 2022.

6. Analysis of Pedagogical Results

A superficial reading, supported by quantitative analysis, confirms that students who achieved higher overall results in the survey exercise tended to also receive better grades in design units throughout the nine semesters of the study programme (The 10th semester corresponds to the exclusive development of the master's dissertation; there is no other curricular unit in the semester.). Around 90% of the students fall within these parameters. However, these students also perform well in other units, indicating that the correlation cannot be considered coincidental. Thus, a more focused interpretation of the results is proposed, less influenced by external factors. Let us limit this reflection to a particular component of the process: the creation of the matrix and its subsequent influence on the development of the entire process.

It is considered that the quality of the matrix is not merely linked to the geometric precision of the scaled transposition of the real object. The quantity and relevance of the working annotations are essential for understanding the constructive/programmatic relationship with the formal solution. Annotations (notes transcribed from student projects from the 2013–2014 academic year, involving the survey of horizontal water mills located in Aldeia da Montaria, Serra d'Arga, Viana do Castelo; conducted as part of the Project Analysis unit, 1st year, 1st semester) such as "alignment of the window's vertical axis with the centre of the millstone", "tangential misalignment of the water channel (cubo) in relation to the axis of the mechanism", "door lintel level with the roof eaves", "stone masonry courses significantly smaller between the level of the eaves and the ridge", "the start of the 'mouth of hell' determined by pre-existing rocky outcrops", and "assumed misalignment between the 'mouth of hell' lintel and the stone flooring" are examples of formal composition rules—in this case, related to a cluster of water mills—which are more important for understanding the architectural phenomenon than the precise measurement of its dimensions.

Out of the 72 students included in the general sample, a comparative analysis was conducted focusing on the 12 students who demonstrated the best results in this particular aspect, considering their performance in the design units throughout their respective study programmes.

The first observation is the ease with which these students organised the technical drawings of their design proposals through layers of sequential information, progressively arranged from general to specific (Figure 12). In eight cases, starting from the 4th year, students developed processes using (though not exclusively) digital design software without significant variation in graphic quality, even enhancing the quality and interactivity of the technical documents.

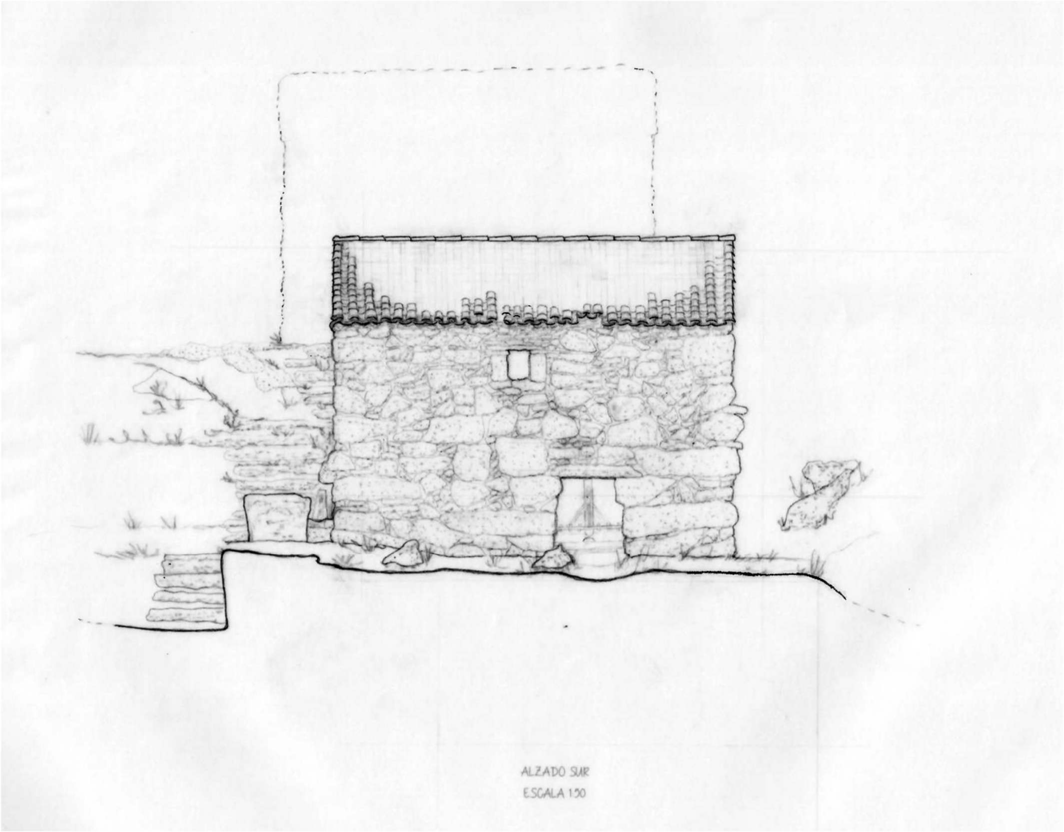

Figure 12. The final representation's accuracy and expression stem from the multilayer system's interaction. Image of a 4-layer overlap. Olalla Rivero, 2017. Picón y Follón, Spain.

In the overall sample, this transition to digital tools applied to only 20% of the students, with the majority of them showing significant difficulties in the development of technical processes. Of the 12 students, 10 demonstrated a high level of consistency in defining the construction systems related to their proposals. Furthermore, five of these students conducted applied research to develop construction solutions tailored to their own projects, which were relatively original and coherent. Three of these cases revealed a particular interest in further exploring related topics in their master's dissertations. Among the remaining sixty cases, only six introduced similar themes in their master's research, with much lower results than those previously mentioned, supporting the hypothesis proposed in this article.

For the 12 selected students, it is evident that all of them achieved higher average grades than the general student average in the design units (12.4 points of 20.00 possible) from the 1st to the 9th semesters. Regardless of the statistical analysis, the most revealing aspect is the explicit need for communication between the conceptual dimension of the project and its technological formalisation (Figure 13). In 11 of the cases, there was an objective and conscious effort to connect the theoretical and formal development of the proposals with the respective construction solution, as evidenced by the consultation of both graphic and written synthesis materials.

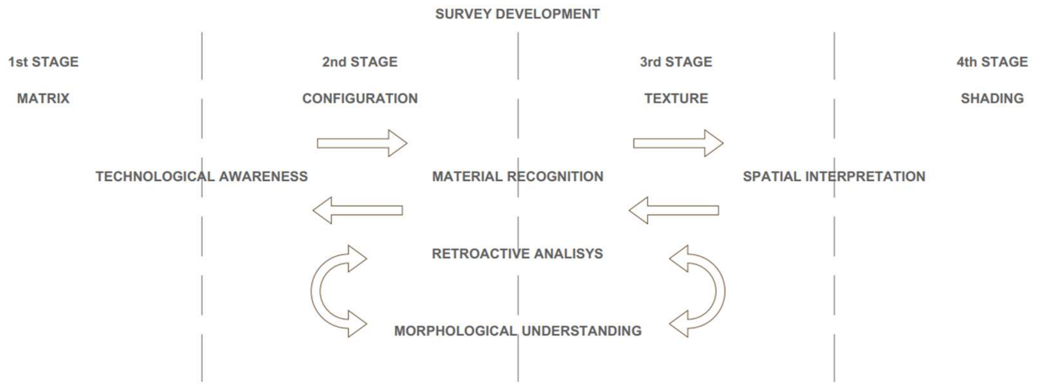

Figure 13. Diagram of students' cognition development identified in this study.

7. Discussion

Photogrammetry and laser scanning have become essential tools in contemporary architectural surveying, offering a non-invasive, highly detailed method for documenting structures in three dimensions [51]. Unlike traditional techniques, it captures both the geometry and texture with precision, making it invaluable in fields such as architecture, archaeology, heritage management, and civil engineering. Its ability to generate detailed 3D models from 2D images enables the accurate analysis of materials and structures while preserving fragile environments [52]. Recent advancements in photogrammetric devices, often equipped with automated features, have further enhanced accessibility, streamlining workflows for professionals and students alike [53].

A key advantage of photogrammetry lies in its ability to document complex geometries and remote sites with minimal disruption. It is particularly useful for surveying historical buildings, hazardous environments, and disaster-affected areas, where traditional methods may be unsafe or impractical [54]. High-resolution imaging and real-time data processing allow for immediate feedback during scanning, ensuring efficiency in applications ranging from architectural conservation to infrastructure monitoring. The integration of photogrammetry with laser scanning and other digital tools is further expanding its potential, improving accuracy in 3D modelling, terrain analysis, and heritage conservation [55].

The increasing adoption of photogrammetry in education reflects its growing importance in architectural and environmental studies. By incorporating it into curricula, students gain practical experience with industry-standard documentation techniques, fostering a deeper understanding of spatial representation and material analysis [56]. As computational capabilities advance, photogrammetry is set to become even more integral to surveying, design, and heritage preservation. When analysing the curriculum of top-ranked institutions, the digital transition does not appear as a distinct milestone or structured syllabus. The main evidence lies in the varied subjects and timing, aside from the standard inclusion of 2D and 3D software skills for technical representation, typically after the first year [57]. Meanwhile, visual thinking through drawing remains a fundamental aspect of architectural education, serving as a retrospective synthesis of design interpretation and development, regardless of the representation method [2].

In light of the presented results, it is evident that a structured and methodical approach to architectural education, as demonstrated through exercises like the stated one, facilitates not only a deeper understanding of design principles but also a stronger integration of technical and conceptual aspects of architectural projects [4]. The correlation between success in drawing exercises and higher performance in design projects aligns with current pedagogical shifts towards integrating practical skills with theoretical learning [58]. This method also echoes broader trends in architectural education, where there is an increasing emphasis on synthesising traditional methodologies with contemporary digital tools [59]. This study defends that the integration of graphical decomposition exercises, exploring technological premises, early in education fosters a stronger comprehension of spatial relationships and materiality, which is crucial for students' success in more complex design tasks later in their studies. Students' perception on the matter corroborates this interpretation, as stated by one student in the interviews:

> *"The drawings we made in the first years were to me like the instructions of a fragmented building, I started to imagine my proposal like an assemblage of elements in order to overcome my initial difficulties in geometry (. . .) I was not so afraid of developing difficult forms, I started to be more ambitious in my proposals."*

The transition from manual to digital processes, particularly the use of BIM systems, appears to be a significant factor in student success [60]. While some students may struggle with the steep learning curve associated with digital tools, particularly when introduced early without sufficient foundational knowledge, those who build a strong conceptual and technical base through exercises such as the survey tend to excel. This research shows that the slow integration of digital tools, after a thorough grounding in traditional techniques, leads to more profound architectural understanding and better project outcomes. An undergraduate student stated the following during the 1st-cycle interview series:

> *"The understanding of a layered representation register was a key factor when I moved to the Revit [2015] program, and had to deal with the management of technological features during the Design process."*

Despite their realism and swift execution, photogrammetric surveys are limited to surface representation and constrained by surface luminosity. Their development does not enable first-year students to grasp the technical (technological and functional) relationships within formal resolution. The usefulness and effectiveness of these interpretative exercises for early-year students are almost entirely restricted to mastering surveying equipment and digital processing software, which is considered too limiting for the skills targeted in project units. According to Edwards [33], the passiveness of the process is not enough to trigger the abstract perception of the observed phenomenon. Moreover, a lack of technical knowledge also compromises the quality of the survey and its practical application [51]. For instance, in Figure 14, the student, despite resorting to a digital survey, failed to define (demonstrate and understand) the relationship between the driving mechanism, the interior, and the spatial configuration of the surveyed mill in the subsequent graphical documentation. Conversely, applying these tools in later years, after undergoing the necessary processes, enhances and improves the quality of digital modelling using laser and photographic recording, as illustrated in Figure 15. In the third-year Simulation and Modelling II unit, taught by one of the authors, an exercise involves digitally modelling buildings previously studied in the first year.

Figure 14. Example of a first-year student's 3D digital model, after a photogrammetric survey, revealing inadequacy in interpreting extra-formal relationships. Pablo Freiría, 2020/2021.

Figure 15. Example of a third-year student's 3D digital model processing, based on a photogrammetric survey. Martín Torres, 2018/2019.

Students who exhibit a thorough grasp of both the conceptual narrative and the technical resolution of their designs tend to perform better across multiple assessment points, supporting the notion that a balanced approach to technical and design education yields the most successful outcomes.

Moreover, the research supports the hypothesis that exercises focused on vernacular building surveys, as advocated by Rapoport, offer students valuable insights into adaptive and sustainable design solutions [27]. This pedagogical strategy, emphasising critical thinking over replication, prepares students to engage creatively with contemporary architectural challenges. The integration of vernacular strategies within a modern architectural curriculum encourages students to develop innovative yet contextually appropriate solutions [49]. These exercises promote not only technical skill but also cultural literacy, enabling students to approach design with a sensitivity to local materials, techniques, and environmental conditions, all of which are increasingly important in global architectural practice [61]. Several of the interviewed master's students stated that is very common to resort to analytical sketches of traditional construction in order to develop their new building details. One of them stated:

> *"It's all there, it is like I can summarise the problem and then rearrange it according current materials."*

The present study's findings align with broader discussions on the evolution of architectural education, where the combination of traditional design exercises, critical analysis, and digital tool integration is seen as essential for training architects who are both technically proficient and conceptually innovative [62]. The results indicate that a careful progression in teaching methods, moving from manual and theoretical exercises to digital and practical applications, is crucial in ensuring students' ability to synthesise complex design solutions [63]. This phased learning approach ensures that students not only master the tools but also understand the implications of their design decisions, ultimately leading to better educational outcomes and more competent future professionals [24]. As this learning process focuses on the assimilation and mastery of method and procedure, the present study required the implementation of a tutorial system with practical demonstrations in analogous contexts/objects, which inherently limited the size of the working group. Workshop management revealed that teaching groups larger than 15 students per instructor prevented the intended assimilation of knowledge before the final outcome was assessed, leading to a dilution of the exercise and its proper development. Given that the average class size in European universities is significantly higher [64], this presents a procedural challenge for implementing similar exercises, which must always be taken into account.

The increase in class sizes at the institution where this study was conducted (beyond the period considered in the research) led to three key adjustments:

1. An increase in the number of instructors (three per class);
2. The division of classes into three groups with different schedules;
3. The introduction of a peer tutoring system, leveraging students who advance more quickly, generating highly dynamic learning interactions.

Another relevant factor concerns the nature and complexity of the vernacular architecture used as the subject of analysis [65]. In some contexts, the scale and technical intricacy of buildings make it impractical for first-year students to replicate the exercise, particularly within a single semester. However, in the Iberian Peninsula, most vernacular typologies reflect a balance between resource scarcity and material optimisation [60], rooted in Southern Europe's long tradition [66], This typically results in smaller structures with a formal simplicity better suited to the scope of student work. Based on this study's experience, the most significant challenge in implementing these processes is directly linked to students' prior knowledge of descriptive geometry—distinct from technical drawing skills—and the weekly contact hours allocated to semester-long courses. These conditions have been progressively reduced to accelerate student qualification timelines, impacting the depth of learning in this area [67].

This type of study can provide a significant basis for the implementation of concrete pedagogical strategies in architectural education, particularly in the processes of updating study plans [12]. Since the Bologna adaptation, these revisions are typically carried out on an average cycle of seven years, which necessitates an intense and short monitoring period to rigorously validate any structural measures [30].

8. Conclusions

The decomposition implemented in the analytical drawing exercise, formalised through the superimposition of matrix, configuration, texture, and shadow documentation, fosters an awareness of the geometric and technological characteristics of a given architectural object. This is achieved by intersecting its various representation processes [47]. The accumulated experience gained through these abstract interpretations facilitates the progressive recognition of fundamental building components, directly linked to their functional understanding and corresponding design development [68]. This methodology positions the survey exercise as a catalyst for technical knowledge, systematically introducing conventions that can be extrapolated across different building typologies, irrespective of their specific contexts. According to some scholars, this premise is essential for acquiring and consolidating architectural design skills [4].

The objectivity inherent in vernacular examples, as Rapoport asserts, serves as a reliable reference for validating fundamental architectural principles, proving particularly valuable for undergraduate students [27]. The interplay of overlapping layers generates tensions that offer insights into design methodologies, fostering an awareness of the procedures and mechanisms intrinsic to the act of designing. This process establishes a cause–effect interpretation that expands the architectural solution portfolio, as Robin Evans argues [69]. The academic monitoring of students who demonstrated a stronger grasp of this didactic process reveals a clear correlation between their comprehension of construction systems and the formal configuration of their projects. Over 90% of the monitored students exhibited a conceptual narrative aligned with this perspective. This evidence aligns with the views of Jean-Pierre Adam [70], who underscores the necessity of rigorous and detailed studies on construction techniques and material analysis to develop a comprehensive architectural understanding. Regardless of their overall academic performance, these students consistently achieved superior results in the design units, complemented by the clarity and coherence of their graphic communication (Figure 16). A notable observation among the selected sample is their transition to digital tools [71], particularly 3D and parametric modelling. While this transition initially progressed at a slower pace between study cycles, it ultimately proved to be more efficient and productive, particularly in its application to master's dissertations. The current context is especially sensitive to this transition [72], rendering the debate increasingly complex as it pertains to conventional teaching paradigms, the evolving professional market [73], and the pressures exerted by the digital technology industry [74]. A comparative analysis of student work supports the necessity of a gradual learning curve, wherein the integration of technical knowledge in drawing and construction technologies is essential for optimising the efficient use of BIM systems in architectural project development. While external variables must be acknowledged, the inverse scenario—where students who adopted digital tools from their first year failed to achieve satisfactory results in this exercise—reinforces this argument. The observed sample indicates that most of these students exhibit conceptual gaps in their design process, which is reflected in lower grades in the design units, irrespective of their broader academic performance. The imperative to train students in digital tools should not be conflated with urgency. The principles underpinning drawing as a medium for interpreting, conceiving, and developing construction solutions extend far beyond mere figurative representation. Studies by renowned scholars highlight the significance of this phenomenon and the potential of abstraction exercises, which are deeply intertwined with socio-cultural frameworks [75]. Drawing as a process is far more integral to architectural education than the virtuosity of its final output [17]. This debate is not new but remains persistently relevant [76]. This study seeks to reinforce a stance that appears increasingly vulnerable in the face of superficial perceptions, exacerbated by the rapid advancement of self-generative technologies and the consequent redefinition of architectural representation [16–71]. The revision of architectural curricula must swiftly adapt to digital tools and processes. However, it must not neglect the cultivation of abstract thinking. The act of drawing is an indispensable tool for developing spatial perception and technological comprehension, both fundamental to architectural characterisation. The implementation of the Bologna Accord significantly transformed European higher education; it is now time to rationalise its impact and prepare for an update that aligns with contemporary construction requirements and challenges without compromising the foundational principles of architectural education.

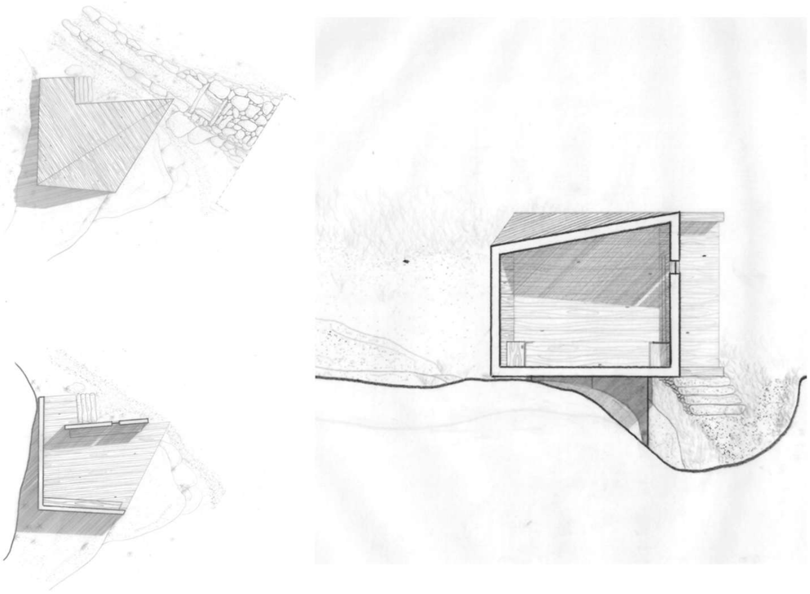

Figure 16. A first-year student's proposal for the relationship between the building system and the spatial configuration. Ivan Vidal, 2014. Picón y Follón, Spain.

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