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Explaining a Model of Indicators Affecting Architecture Students' Creativity, with an Emphasis on Creativity-Based Teaching Methods and the Quality of the Physical Learning Environment, Using the Fuzzy Delphi Method

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ABSTRACT

Contemporary approaches to architectural education emphasize that creativity emerges from the interaction between the physical learning environment, pedagogical strategies, and students' experiential engagement. Enhancing creativity-oriented architectural learning requires identifying key indicators that shape this process. This study aims to determine and explain the indicators influencing the creativity of architecture students, with emphasis on creativity-based instruction and the quality of the physical environment. The research is analytical–applied and follows an interpretive methodological paradigm with developmental characteristics. Data were collected through documentary and library studies. Initial conceptual indicators were extracted using content analysis and inductive reasoning based on theoretical foundations and prior research. Subsequently, the Fuzzy Delphi Method was applied, and a 17-item questionnaire was distributed to 15 experts using the snowball sampling technique. Results from the third Delphi round confirm 11 final indicators, among which "representation culture", "digital technologies, and design thinking displayed the highest influence. The findings highlight three essential components for improving architectural education: spatial design that supports design thinking, digital representational capabilities, and organizational support mechanisms. Applying these validated indicators can improve studio environments, strengthen creative learning processes, and enhance the quality of architectural outcomes.

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INTRODUCTION

In recent decades, the development of creativity in architectural education has been recognized as a fundamental prerequisite for training professionals capable of fluid thinking, problem-solving, and innovative design. This tendency has been reinforced by the emergence of active-learning theories and instructional approaches grounded in the cognitive capacities of learners (Piñones et al., 2025). Global perspectives on architectural education posit that creativity is not merely the outcome of a linear sequence of specialized learning, but rather the result of a dynamic interaction among the physical learning environment, teaching methodologies, and experiential opportunities (Hsueh et al., 2021). Within this framework, contemporary instructional models centered on creativity-oriented learning function as mediating mechanisms that enhance students' abilities to explore, abstract, and synthesize architectural concepts (Sudha & Premkumar, 2025).

The physical environment of architectural vocational schools plays a decisive role in the creative process. The quality of the built environment-including the design of educational spaces, lighting conditions, access to outdoor areas, and opportunities for student participation in spatial design-can directly or indirectly influence motivation, concentration, and the trajectory of creative exploration (Meyer & Fourie, 2018). Empirical studies, for example, demonstrate that multipurpose learning environments with flexible configurations tailored to group needs can significantly strengthen synergy among learning, teamwork, and architectural idea representation (Mahmoud et al., 2020). Theoretically, the notion of the unconventional learning space, which disrupts traditional classroom structures and promotes experiential learning, collaboration, and diverse representational practices, has been identified as a facilitator of creativity in educational literature (Barbosa & Godoy, 2024).

At the micro level, creativity-oriented instruction particularly emphasizes processes such as exploration, conceptual representation, iterative design, and constructive feedback. This instructional approach manifests through activities such as design workshops, case-based architectural critique, and the encouragement of free idea expression without fear of failure, thereby reinforcing intrinsic motivation and tolerance for professional risk-taking (Nursanty et al., 2020). Research on participatory decision-making and team-based reasoning supports the use of collective approaches for aligning expert opinions and identifying latent, multidimensional indicators for evaluating creativity in learning environments (Mahmoud et al., 2023). By integrating insights from experts in architecture, visual arts, and educational psychology, this approach enables the identification and prioritization of influential indicators within a coherent structural model (Wu et al., 2014). At the macro level, constructing a model of indicators affecting the creativity of architecture students requires emphasizing the intersection between two principal domains: creativity-oriented instruction and the quality of the physical learning environment. This intersection functions as an operative nexus through which learning experiences, organizational structures, spatial flexibility, and opportunities for design experimentation become interconnected and mutually reinforcing within a systematic framework (Kim, 2025). In light of ongoing technological transformations and emerging learning paradigms, proposed models are expected to demonstrate adaptability to new educational shifts, including project-based learning and interdisciplinary collaboration (Jahreie et al., 2011). Consequently, an integrative, participatory decision-making approach for extracting indicators across multiple expert perspectives-architecture, urban design, and educational psychology-can lead to the development of a functional and context-responsive model for assessing creativity in architectural schooling (Sanchez et al., 2016).

Ultimately, the purpose of this study is to present a conceptual and operational framework for identifying and modeling the indicators that influence architecture students' creativity-one that simultaneously enhances creativity-oriented instructional strategies and improves the quality of the physical learning environment. Employing the Fuzzy Delphi Method enables the consolidation of expert discourse to determine the prioritization of indicators, thereby strengthening the scientific rigor of the model and increasing its acceptability among architectural educators and policy-makers. This research trajectory not only contributes to the development of architectural education theory but also offers practical strategies for vocational architecture schools, promoting the effective implementation of creativity-oriented learning and the development of high-quality, open, and adaptable educational spaces.

MATERIALS AND METHODS

Creativity in Architectural Learning

Creativity in architectural learning is one of the central concepts in architectural education and is understood as the capacity to generate innovative thinking and novel design solutions. This construct emerges from the interaction of two complementary dimensions: the learner's intrinsic dispositions such as curiosity, cognitive risk-taking, and willingness to experiment with diverse modes of conceptual exploration and the pedagogical context that provides opportunities for experimentation, multimodal representation, and engagement with architectural precedents. Research on creative learning consistently demonstrates that creativity is not the product of memorized instructional content; rather, it results from active learning processes characterized by student participation, multiple representational forms, and constructive feedback (Weisberg et al., 2013). Within this frame, creative learning is typically associated with several core components: synthesizing knowledge across different domains, generating novel ideas within project constraints, and engaging in rigorous evaluation and iterative refinement during the design process (Nayak, 2007). Inquiry-based and problem-based learning approaches, by offering open-ended challenges, foster the development of nonlinear cognitive models an aspect particularly significant in architecture, where design requires the integration of aesthetics, functionality, and human spatial experience (Laal & Laal, 2012). From a cognitive perspective, theories of metacognitive and higher-order thinking emphasize that learners must employ varied representational strategies such as conceptual diagrams, three-dimensional models, and comparative case analyses to simultaneously examine spatial relationships and design structures. This process enhances cognitive flexibility and spatial-analytic competence. Alongside these individual factors, the learning environment plays a critical role; an environment that provides a safe space for idea expression, embraces failure as an inherent part of the design process, and offers supportive feedback can cultivate intrinsic motivation and the inclination toward innovation (Lucas, 2016). Therefore, creativity in learning is shaped not only by individual abilities but also by dynamic interaction with educational resources, representational diversity, and opportunities for participation in design processes. Recent studies have shown that the incorporation of digital technologies and well-designed digital learning environments expands the scope of creative expression and facilitates multisensory and multimedia integration capabilities particularly relevant in architectural education (Nussbaum, 2013). Accordingly, a model of indicators influencing architectural students' creativity must simultaneously consider the advancement of creativity-oriented learning and improvements in the physical learning environment to enable more precise and strategic assessment; in other words, creativity is a dynamic process strengthened through varied representational practices and continuous feedback (Kim, 2018).

From an instructional standpoint, designing courses that present open-ended questions and appropriately challenging problems while providing opportunities for independent or collaborative exploration, experimentation, and revision can foster creative learning processes and yield higher-quality, more innovative educational outcomes. Developmental research further shows that the interplay of active learning, multimodal representation, and iterative constructive feedback can lead to higher-order creativity, such as design thinking and the ability to synthesize diverse concepts—an ability that, in architecture, translates into creating innovative spatial solutions with multifaceted functions (Runco, 2004). Thus, creativity in learning should be conceptualized as a dynamic process nourished simultaneously by intrinsic motivations, pedagogical opportunities, and environmental support, enabling the emergence of new architectural discourses and innovative design responses

Creativity-Oriented Instruction in Architectural Learning

Creativity-oriented instruction in architectural learning constitutes one of the fundamental pillars in cultivating students' capacity for innovative design. Through the integration of active learning approaches, multimodal representations, and collaborative engagement, this instructional model enables higher levels of spatial understanding, functional analysis of architectural spaces, and the generation of novel design ideas. Within this framework, the primary focus is placed on the learning process rather than the mere acquisition of content. In other words, learning is conceptualized as a dynamic experience structured around architectural projects, design presentations, and iterative critiques through which students not only acquire theoretical knowledge but also engage with methods of creating, testing, evaluating, and refining design ideas (Sawyer, 2015). From the perspective of educational psychology, creativity-oriented instruction facilitates a safe environment for idea expression, embraces failure as an essential component of the design process, and encourages divergent and nonlinear thinking elements considered critical drivers of creative development (Beghetto & Kaufman, 2014).

Through problem-based workshops, case studies of exemplary architectural works, and various representational practices such as three-dimensional modeling, architectural sketching, and spatial calligraphy, students are afforded opportunities to experience the design process step-by-step and utilize constructive feedback to enhance their ideas (Kazakçı, 2019). Research further indicates that learning environments emphasizing collaboration, professional dialogue, and active participation within design teams significantly reinforce creativity criteria in architectural projects and capture the inherent complexity of architectural thinking through interactive means (O'Brien & Kearney, 2015). Theoretically, creativity-oriented instruction is grounded in models of design thinking, the integration of digital technologies, and critical approaches to spatial experience enabling students to examine architectural problems from multiple perspectives and formulate innovative solutions (Gouveia et al., 2020). Within this context, instructional layers such as multimodal representation strategies, constructive feedback cycles, and process-based assessment gain increasing significance. These mechanisms, through iterative design and systematic revision, contribute to improving the quality of architectural outputs (Resendes & Begega, 2023). Given recent advancements in educational technologies and the growing need for advanced learning models, creativity-oriented instruction must be designed to integrate social interaction, hands-on engagement with materials and spatial assemblies, and analytic reasoning all of which strengthen representational skills, spatial reasoning, and collective creativity (Sun et al., 2022). The overarching goal of this approach is to create a learning environment in which students, through strategies of exploration, experimentation, and revision, acquire a deeper understanding of architectural space, its functions, and the transformation of ideas into feasible design proposals.

This process ultimately leads to innovative architectural outcomes grounded in cognitive design models and spatial quality (Higgins et al., 2011). Moreover, the successful implementation of creativity-oriented instruction requires alignment with the physical learning environment, available design facilities, and effective assessment models. Using the fuzzy Delphi method to synthesize expert perspectives in architecture, pedagogy, and educational psychology facilitates the identification and prioritization of influential indicators, thereby ensuring robust and widely accepted evaluation frameworks (Zhao & Li, 2020).

Accordingly, the following table summarizes relevant theories and empirical studies within the associated research domain (Tab.1).

Table 1: Review of Theories Related to Creativity-Oriented Instruction in Architectural Learning

Author	Year	Research Topic	Description	Findings	Core Concept
Beghetto, R. & Kaufman, J.	2014	Creativity in education	Creativity approaches based on divergent thinking and learner abilities	Creative-oriented instruction increases learning motivation and innovation in architectural projects	Creativity as a process, not merely an outcome
Runco, M. A. & Jaeger, G.	2012	Creative processes in learning	Models of idea generation and creative cognition	Educational interactions involving multiple representations enhance creativity	Novel idea generation accompanied by structured evaluation
Sawyer, R.	2015	Studio-based learning	Learning through exploration and interactive design	Strengthens problem-solving and design thinking skills	Experiential and collaborative learning as foundation
Niu, A. et al.	2021	Technology & creativity in architecture	Digital learning and multimedia environments	Enhances spatial reasoning and representational creativity	Technology expands creative learning capacities
O'Brien, K. & Kearney, M.	2015	Non-traditional learning environments	Spatial design for creative learning	Increased student participation and architectural idea articulation	Open, flexible spaces foster creative expression
Kazakçı, S.	2019	Problem-based architectural studios	Problem-based architectural studios	Improves design capability and teamwork	Problem-orientation as key driver of creativity
Gouda, M. et al.	2021	Decision-making models in architectural education	Decision-making models in architectural education	Produces more precise models with higher acceptance	Fuzzy Delphi for expert consensus

Sun, Y. et al.	2022	Project-based learning in architecture	Project-based learning in architecture	Greater design performance and constructive critique	Project-driven learning enhances creativity
Taylor, P. et al.	2018	Multi-purpose learning spaces	Collaborative adaptive spatial design	Increases synergy between learning and design	Adaptable spaces as catalyst for innovation
Resendes, C., & Begega, M.	2023	Process-oriented assessment	Emphasizes iterative revision and constructive feedback to improve architectural projects	Enhances the quality of design outputs and strengthens the learning process	Process-oriented assessment over outcome-focused evaluation
Gouveia, S., & colleagues	2020	Design thinking and technology	Integrates design-thinking strategies with digital tools in architectural studios	Improves spatial reasoning and promotes collaborative creativity	Technology-enhanced design thinking
Lee, J., & Kolodziej, A.	2021	Creative learning in digital environments	Explores digital learning environments, including AR/VR applications in architectural design	Enables multisensory representations and collaborative ideation	Effective evaluation models for architectural pedagogy
Zhao, X., & Li, Y.	2020	Sustainability assessment in architectural education	Combines educational indicators with principles of spatial sustainability	Provides actionable strategies for implementing sustainable architectural studios	Efficient evaluation leads to sustainable learning processes
Higgins, S., et al.	2021	Learning spaces and innovation	Highlights open layouts, optimal lighting, and the balance between autonomy and collaboration	Demonstrates that innovative learning outcomes correlate with well-designed educational spaces	Learning space plays a significant role in fostering innovation
Runco, M. A., & Acar, S.	2020	Creativity and individual development	Investigates the role of individual dispositions, motivation, and educational environment in shaping creativity	Shows strong correlations between intrinsic motivation and creative performance in architectural learning	Creativity development through supportive educational environments

The Role of Physical Spatial Quality in Creativity-Centered Architectural Learning

The quality of the physical learning environment is a critical factor in supporting creativity-centered learning in architectural education, functioning as the spatial foundation through which creative and design-oriented thinking is materialized. This concept encompasses three core dimensions: flexible spatial configurations that enable adaptive use and active student participation; environmental conditions including lighting, acoustics, and sound quality that influence concentration and cognitive engagement; and specialized facilities and tools that support spatial exploration, physical and digital modeling, and multimodal representation. Research indicates that open and adaptable learning environments enhance student engagement, motivation, and the quality of spatial representations by providing diverse opportunities for collaboration, design critiques, interactive exhibitions, and multisensory representation (O'Brien & Kearney, 2015).

From the perspective of instructional design theories, the physical environment operates as a "design language," enabling learners to integrate visual, physical, and symbolic modes of expression while synchronizing with the iterative processes of design thinking (Gouda et al., 2021). This alignment between space and creativity-centered learning processes strengthens opportunities for exploration, synthesis of concepts, and diverse spatial representations, ultimately leading to higher-quality and more innovative architectural outcomes (Higgins et al., 2011). In practical terms, the quality of the physical environment includes its accessibility, safety, and the usability of workshop areas, modeling studios, and presentation rooms. Spaces designed to support teamwork and idea exchange equipped with writable surfaces, display walls, and flexible partitions—facilitate continuous visualization of group work and enable immediate and constructive feedback (Taylor et al., 2018). Studies on unconventional learning environments suggest that the integration of open, adaptable, and experience-rich spaces increases the quality of spatial representations and enhances students' design abilities, particularly in architecture, where the relationship between form, function, and human experience is central (Condie & Morin, 2018). Furthermore, appropriate acoustic design and the presence of natural or well-orchestrated artificial lighting contribute to improved concentration, reduced distraction, and enhanced spatial reasoning and representation performance (Barron et al., 2019). Multi-purpose spaces that allow functional changes based on group needs can also foster collaboration, support iterative review processes, and accelerate design refinement (Taylor et al., 2018). From an architectural-pedagogical standpoint, the interaction between spatial quality and creativity is most effective when the environment is aligned with creativity-centered instructional strategies. Spaces that support independent and collaborative exploration, model-making, spatial experimentation, and comparative representation foster non-linear thinking and strengthen spatial reasoning (Sawyer, 2015). These features, combined with opportunities for constructive feedback, peer critique, and iterative revision, enhance both the design process and its resulting outputs (Resendes & Begega, 2023). Accordingly, any structural model of creativity indicators within architectural learning must integrate spatial quality with creativity-centered pedagogical mechanisms to ensure sustainable and continuous implementation. In the following section, a table is presented summarizing the theoretical foundations and recent studies relevant to this domain (Tab.2).

Table 2: Review of Theories Related to Physical Learning Space Quality in Creative-Based Learning

Author	Year	Research Topic	Theory / Theoretical Lens	Description	Findings	Core Concept
O'Brien, K. & Kearney, M.	2015	Unconventional learning spaces in architecture	Spatial design for creative learning	Multimodal, flexible spaces enabling collaboration and representation	Increased participation and expression of design ideas	Learning spaces influencing creativity

Gouda, M. et al.	2021	Decision-making models in architectural education	Fuzzy Delphi for indicator extraction	Aggregation of expert opinions to prioritize indicators	More accurate and acceptable evaluation models	Fuzzy Delphi for consensus-building
Higgins, S. et al.	2011	Learning space and innovation	Spatial design for innovation	Open spaces, optimized lighting, and balance of independence–collaboration	Educational innovation enhanced by effective spatial design	Learning space influencing innovation
Taylor, P. et al.	2018	Multi-functional educational spaces	Adaptability and collaboration	Spatial reconfiguration for diverse activities	Increased synergy between learning and design	Adaptable, collaboration-centered spaces
Resendes, C. & Begega, M.	2023	Process-oriented assessment	Process-based evaluation in architecture	Regular revisions and structured feedback during design	Improved learning process and output quality	Process-based assessment
Zhao, X. & Li, Y.	2020	Sustainability evaluation in architectural education	Efficient evaluation models	Integration of pedagogical indicators with spatial sustainability	Practical strategies for sustainable architecture classrooms	Effective evaluation & sustainable learning
Barron, P. et al.	2019	Acoustics and lighting in architecture studios	Effective light & acoustic design	Influence of lighting and sound quality on focus and representation	Enhanced concentration and quality of spatial representation	Lighting & acoustics improving learning
Condie, R. & Morin, A.	2018	Unconventional learning environments	Design of non-traditional learning spaces	Open, flexible environments promoting collaboration	Increased group activity and diverse representations	Non-traditional spaces enhancing creativity
Sawer, R.	2015	Project-based learning in architecture	Experiential learning & design exploration	Studio workshops emphasizing design exploration and representation	Improved spatial reasoning and group creativity	Project-based and exploratory design learning
Lee, J. & Kolodziej, A.	2021	Digital environments in architecture	Educational technologies and creativity	Use of digital platforms, augmented reality (AR), and virtual reality (VR) to support design learning	Enhanced multisensory representations and collaborative ideation	Educational technology as an enabler of creativity

Niu, A. et al.	2021	Technology and creativity in architecture	Digital learning and multimedia environments	Digital modeling frameworks and multisensory representational tools	Expanded scope of spatial representation and improved spatial reasoning	Digital learning as a creativity enhancer

Table 3: Key Factors Influencing Creativity of Architecture Students with a Focus on Creative-Based Pedagogy and Physical Learning Environment Quality

Factor	Indicator	Type of Factor	Assessment Method	Concept Addressed
Group Collaboration	Cooperation, idea exchange	Social	Observation of group processes; participation assessment	Capacity for collaborative work and collective ideation during the design process
Design Thinking	Problem-solving, spatial reasoning	Cognitive	Evaluation of design problem-solving tasks using spatial reasoning criteria	Ability to apply design thinking in generating innovative architectural solutions
Multisensory Spatial Representation	3D modeling, architectural drawing	Spatial	Analysis of representational diversity and use of media tools	Enrichment of representational tools and transforming design ideas into comprehensible spatial outputs
Spatial Flexibility	Adaptability, multi-functionality	Spatial	Usability testing; evaluation of spatial changeability	Relationship between spatial configuration and the production of creative design solutions
Effective Lighting and Acoustics	Illumination quality, sound frame	Sensory	Measurement of lighting and sound levels; evaluation of perceived comfort	Impact of lighting and acoustic conditions on concentration, imagination, and spatial exploration
Accessibility	Spatial access, ease of use	Spatial	Assessment of accessibility standards; student interviews	Influence of accessibility on engagement, movement, and effective use of learning spaces
Learning Space Safety	Workshop safety, perceived security	Psychological	Risk assessment; perception-of-safety questionnaire	Effect of physical safety on risk-taking, experimentation, and creative expression
Constructive Feedback	Design critique, formative feedback	Educational	Feedback cycles; process-oriented assessment	Strengthening learning outcomes through iterative feedback and design refinement
Unconventional Learning Spaces	Nontraditional environments, open spaces	Spatial	Qualitative interviews; card-based representational methods	Influence of open and unconventional settings on creativity, curiosity, and experimentation

Managerial Support	Institutional backing, policy support	Organizational	Organizational signal analysis; interviews with administrators	Role of institutional support in facilitating creative-based pedagogy and resource provision
Digital Technologies	Digital tools, VR/AR environments	Technological	Evaluation of design software proficiency; assessment of VR/AR integration	Expansion of digital representation capabilities and enhancement of collaborative design processes
Representation Culture	Openness to diverse ideas, design tolerance	Cultural	Attitudinal questionnaires; group interviews	Promoting acceptance of diverse representational styles and fostering spatial expression freedom
Sustainable Design Principles	Spatial and environmental sustainability	Procedural	Evaluation of sustainability indicators within student designs	Examining the influence of sustainability integration on creative design processes
Design Critique	Peer review, analytical evaluation	Procedural	Critique sessions; rubric-based review	Enhancing analytical thinking and iterative improvement of design ideas
Project-Based Learning	Project orientation, design process continuity	Educational	Evaluation of project development stages	Alignment of learning progression with architectural outputs and spatial representations
Communication Skills	Concept delivery, disciplinary dialogue	Social	Presentation assessment; peer evaluation	Influence of communication skills on clarity of design ideas and effective articulation of spatial concepts
Intrinsic Motivation	Curiosity, exploratory drive	Psychological	Motivational questionnaires; self-report scales	Role of intrinsic motivation in sustaining creative engagement and exploratory design behavior

Methodology

The present study employs an analytical research design with an applied purpose. The research paradigm is interpretive, and given the qualitative nature of the study, it also possesses developmental characteristics. Data collection was conducted through documentary and library-based methods, utilizing academic sources such as scholarly articles, reports, and expert consultations. Initially, content analysis and inductive reasoning were employed to develop the primary conceptual structure and to extract the latent factors derived from the theoretical foundations and prior literature. Subsequently, the fuzzy Delphi method, as a participatory decision-making approach, was applied. In this phase, a total of 17 questions were developed in the form of a snowball-sampling questionnaire and distributed using the Google Form tool to a panel of 15 experts and specialists. Using open-ended questions within the Delphi rounds and analyzing the responses in subsequent stages enabled the researchers to assess consensus formation among experts and determine theoretical saturation—both of which are key qualitative strategies for validating data interpretation in this study. Following the finalization of the Delphi rounds, factors with a mean score higher than 4 were retained. These validated indicators constituted the finalized model of influential factors and were ultimately integrated into the proposed conceptual framework of the research.

DISCUSSION AND FINDINGS

Delphi Method Results

In this study, the cognitive dimension of creativity in learning, along with the quality of the physical learning environment—emphasizing creative-based instructional approaches for architecture students—served as the primary constructs extracted from the theoretical foundations. Subsequently, the key components and criteria were identified in alignment with the research objectives. These subcomponents were conceptualized based on experts' cognitive perspectives as well as the structural influence of primary constructs on secondary constructs.

All elements were compiled into an integrated package and presented to a panel of experts to facilitate implementation of the Delphi method. A total of 17 factors were evaluated through this process to determine the final indicators. These factors included: group collaboration, design thinking, multisensory spatial representation, spatial flexibility, effective lighting and acoustics, accessibility, learning-space safety, constructive feedback, unconventional learning spaces, managerial support, digital technologies, representational culture, principles of sustainable design, design critique, project-based learning, communication skills, and intrinsic motivation.

Delphi Method Implementation

Round One

In the first round, members of the expert panel identified 14 out of the 17 factors extracted from validated prior studies (see Tab. 3) as having moderate, high, or very high levels of influence in developing the final framework of indicators for the model assessing creativity among architecture students, with emphasis on creative-based instructional approaches and the quality of the physical learning environment. Detailed findings and descriptive results related to the first round of the questionnaire distribution are presented in the table below. The factors unconventional learning spaces, principles of sustainable design, and intrinsic motivation, due to having a mean importance score below 2.5, were excluded from subsequent Delphi rounds (see Tab. 4 and Fig. 1).

Table 4: First Stage of the Fuzzy Method in Developing the Final Indicators of the Model of Factors Affecting Architecture Students' Creativity, with an Emphasis on Creativity-Based Teaching Methods and the Quality of the Physical Learning Environment (Source: Authors)

No.	Factors	N	Mean	Std. Deviation	Minimum	Maximum
1	Group Collaboration	15	4/12	0/52	1	5
2	Design Thinking	15	4/15	0/63	1	5
3	Multisensory Spatial Representation	15	3/85	0/45	1	5
4	Spatial Flexibility	15	4/07	0/76	1	5
5	Effective Lighting and Acoustics	15	3/86	0/51	1	5
6	Accessibility	15	3/59	0/34	1	5
7	Learning Space Safety	15	3/45	0/38	1	5

8	Constructive Feedback	15	3/28	0/45	1	5
9	Managerial Support	15	3/70	0/48	1	5
10	Digital Technologies	15	4/25	0/53	1	5
11	Representation Culture	15	4/27	0/71	1	5
12	Design Critique	15	3/56	0/35	1	5
13	Project-Based Learning	15	3/95	0/54	1	5
14	Communication Skills	15	3/85	0/34	1	5

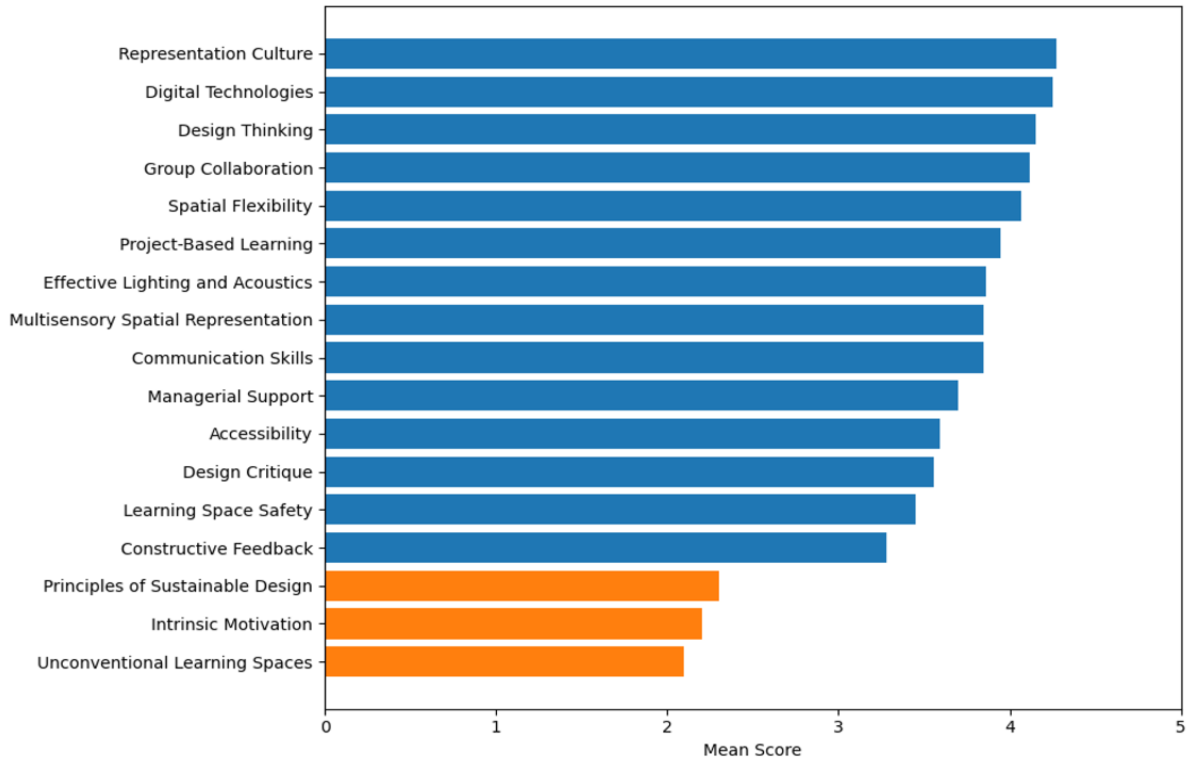

Figure 1: Export Evaluation Factors (Delphi frist round)

In Round One of the Delphi process, expert evaluations indicated that 14 out of the 17 initially identified factors exerted moderate to very high levels of influence on architecture students' creativity, particularly with respect to creativity-based instructional approaches and the quality of the physical learning environment. Among these, Digital Technologies, Representation Culture, Design Thinking, Group Collaboration, and Spatial Flexibility achieved the highest mean scores, reflecting a strong level of expert consensus regarding their pivotal role in fostering creative learning outcomes. These findings underscore the significance of interactive, technology-enhanced, and collaborative educational settings in architectural education. Conversely, Unconventional Learning Spaces, Principles of Sustainable Design, and Intrinsic Motivation received mean importance scores below the predefined cutoff value (Mean < 2.5) and were therefore excluded from subsequent Delphi rounds. Overall, the results of the first Delphi round reveal a clear convergence of expert opinions toward prioritizing pedagogical, managerial, and spatial quality-related factors, thereby establishing a robust empirical basis for refining and validating the indicator framework in the subsequent stages of the Delphi process.(Fig.1)

Round Two

Following the completion of the first round of evaluation and the assessment of expert panel opinions regarding the factors extracted from the theoretical foundations—along with the additional suggestions provided by the panel members—all factors identified in the literature, together with the mean scores from Round One and each member's previous response, were redistributed among the experts in this round to ensure methodological rigor. In Round Two, panel members identified 11 out of the 13 factors presented as having high or very high influence (i.e., mean score greater than 3.5) on the development of the research framework. Detailed results associated with the second round of questionnaire distribution are presented in the following table. The Kendall's coefficient of concordance (W) calculated for panel responses regarding the ranking of the 11 influential factors was 0.765, indicating a strong level of agreement among the experts (see Tab.5). It should be noted that the factors learning space safety (mean score = 3.48), constructive feedback (mean score = 3.32), and design critique (mean score = 3.44) were removed from the subsequent Delphi process due to not meeting the required threshold. It should be noted that the factors learning space safety (mean score = 3.48), constructive feedback (mean score = 3.32), and design critique (mean score = 3.44) were removed from the subsequent Delphi process due to not meeting the required threshold.

Table 5: Second Phase of the Fuzzy Method for Developing the Final Indicators of the Model: Factors Influencing Architectural Students' Creativity with a Focus on Creative-Based Pedagogy and Physical Learning Environment Quality (Source: Authors)

No.	Factors	15N	Mean	Std. Deviation	Minimum	Maximum
1	Group Collaboration	15	4/18	0/48	2	5
2	Design Thinking	15	4/21	0/56	2	5
3	Multisensory Spatial Representation	15	3/92	0/42	2	5
4	Spatial Flexibility	15	4/14	0/65	2	5
5	Effective Lighting and Acoustics	15	3/94	0/48	2	5
6	Accessibility	15	3/66	0/30	2	5
7	Learning Space Safety	15	3/78	0/41	2	5
8	Digital Technologies	15	4/29	0/43	2	5
9	Representation Culture	15	4/34	0/53	2	5
10	Project-Based Learning	15	4/05	0/47	2	5
11	Communication Skills	15	3/92	0/29	2	5

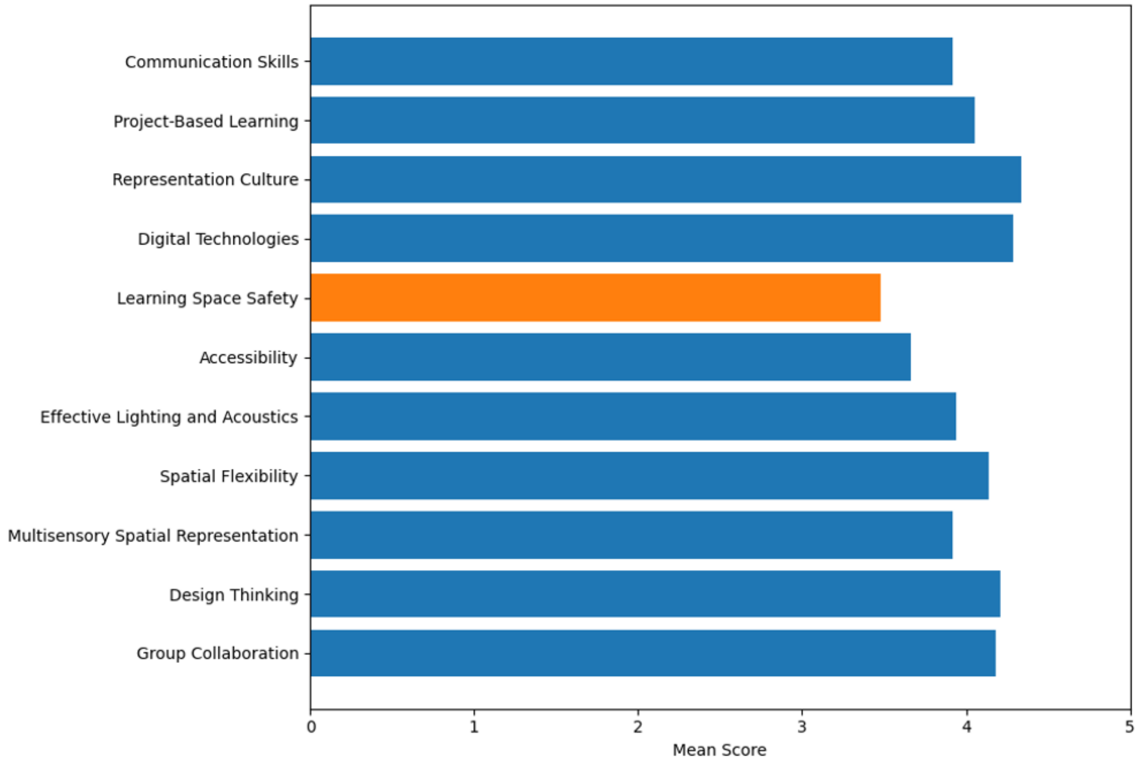

Figure 2: Expert Evaluation of Factors Affecting Architectural Students' Creativity (Delphi second round)

In Round Two of the Delphi process, expert consensus became more pronounced, as 11 out of the 13 evaluated factors achieved high to very high levels of influence, with mean scores exceeding the threshold of 3.5. Factors such as Representation Culture, Digital Technologies, Design Thinking, Spatial Flexibility, and Group Collaboration recorded the highest mean values, reflecting strong agreement on the central role of cognitive, technological, and collaborative dimensions in fostering creativity among architecture students. The calculated Kendall's coefficient of concordance (W = 0.765) further confirms a strong level of consistency among expert judgments, indicating methodological robustness of this round. In contrast, Learning Space Safety, Constructive Feedback, and Design Critique failed to meet the required threshold and were consequently excluded from subsequent rounds, suggesting that experts perceived these factors as secondary compared to pedagogical strategies and spatial–technological qualities. Overall, the results of Round Two demonstrate a refined convergence toward a stable set of influential indicators, strengthening the conceptual foundation for the final model.(Fig.2)

Round Three

In the third round of developing the final research framework, all factors—along with the mean scores from Round Two and each member's previous evaluation—were redistributed among the expert panel to complete the iterative refinement process. Detailed results associated with the third round of questionnaire distribution are presented in the following table. In this stage, all 11 factors were confirmed by the expert panel as having a "very high" level of influence, each obtaining a mean score greater than 4, thereby meeting the predefined acceptance threshold. Furthermore, Kendall's coefficient of concordance (W) for the ranking of the 11 factors was calculated as 0.790, indicating a strong and strengthened level of agreement among the experts (Tab.6).

Table 6: Third Stage of the Fuzzy Method in Formulating the Final Indicators of the Model of Factors Influencing Architectural Students' Creativity, with a Focus on Creative-Based Pedagogy and the Quality of the Physical Learning Environment (Source: Authors)

No.	Factors	15N	Mean	Std. Deviation	Minimum	Maximum
1	Group Collaboration	15	4/22	0/25	3	5
2	Design Thinking	15	4/25	0/26	3	5
3	Multisensory Spatial Representation	15	4/05	0/28	3	5
4	Spatial Flexibility	15	4/19	0/42	3	5
5	Effective Lighting and Acoustics	15	4/03	0/36	3	5
6	Accessibility	15	4/06	0/21	3	5
7	Learning Space Safety	15	4/03	0/22	3	5
8	Digital Technologies	15	4/36	0/25	3	5
9	Representation Culture	15	4/41	0/35	3	5
10	Project-Based Learning	15	4/12	0/32	3	5
11	Communication Skills	15	4/10	0/17	3	5

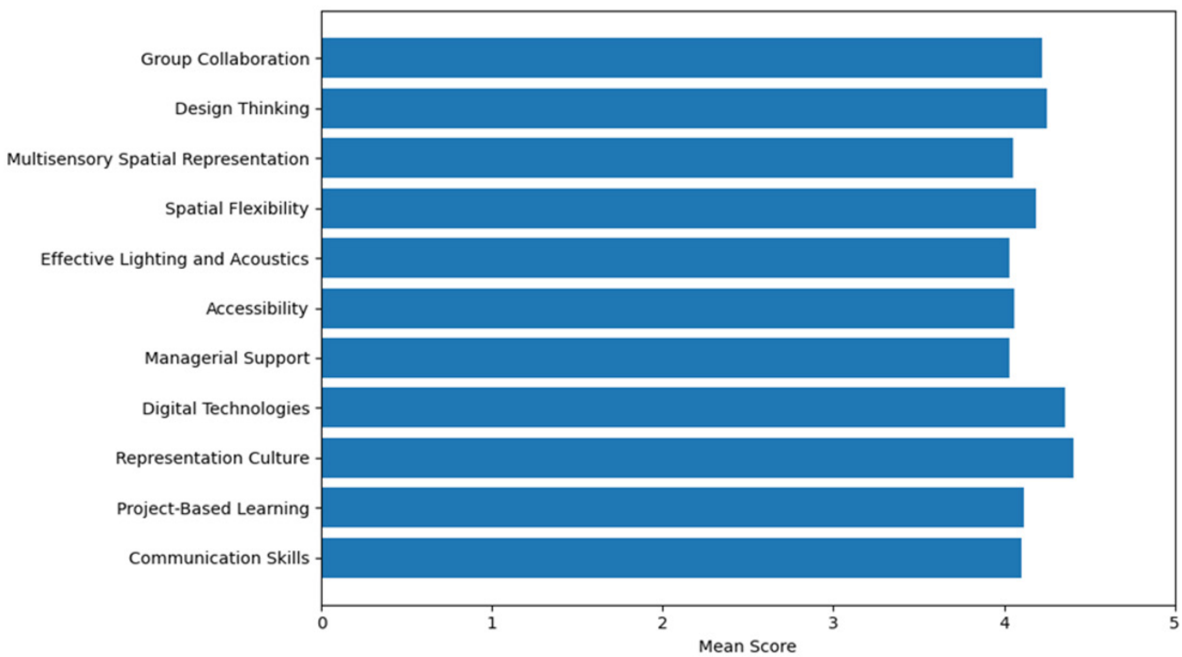

Figure 3: Export Evaluation Factors (Delphi third round)

In Round Three of the Delphi process, a full consensus was achieved among the expert panel, as all 11 retained factors attained a “very high” level of influence, each with a mean score exceeding the acceptance threshold of 4.0. Factors such as Representation Culture, Digital Technologies, Design Thinking, and Group Collaboration recorded the highest mean values, underscoring the dominant role of cognitive–cultural competencies and technology-enhanced pedagogical strategies in fostering architectural creativity. The increased Kendall’s coefficient of concordance (W = 0.790) compared to Round Two indicates a strengthened and stable agreement among experts, confirming the reliability and maturity of the final indicator set. The narrow dispersion of mean scores and reduced standard deviations further suggest convergence in expert judgment, reflecting a refined understanding of the interrelationship between creative-based pedagogy and the quality of the physical learning environment. Overall, Round Three validates the finalized framework as a robust and coherent model for assessing creativity in architectural education.(Fig.3)

Reasons for Termination of the Delphi Inquiry

The results obtained across the three rounds of the Delphi process indicate that consensus among the panel members was achieved, and therefore continuation of further rounds was deemed unnecessary. The main reasons for terminating the inquiry are as follows:

•In the second round, more than 50% of the panel members selected 14 out of the 17 factors those with a mean score greater than 2.5 as influential components in formulating the final index model for creativity among architecture students, with a focus on creativity-oriented pedagogy and the quality of the physical learning environment.

•The standard deviation of the participants’ responses regarding the importance of the factors in the second round showed a substantial decrease compared to the previous round, indicating convergence of opinions.

•The standard deviation of the participants’ responses in the third round exhibited an even more notable reduction compared to the earlier rounds, further confirming the stabilization of expert judgments.

•Kendall’s coefficient of concordance for the ranking of the factors in the third round reached 0.790. Given that the number of panel members exceeded ten, this level of Kendall’s W is considered statistically significant and indicative of a strong agreement.

•The increase in Kendall’s coefficient from the second to the third round was only 0.025, suggesting that the level of consensus had plateaued, and additional rounds would not meaningfully alter the collective opinion.

The scores assigned by experts indicate that “representation culture,” “digital technologies,” and “design thinking” received the highest mean values, implying that these factors have the most substantial influence in shaping the structural model.

DISCUSSION AND FINDINGS

In line with the objective of the present study which sought to identify and articulate the key indicators influencing creativity among architecture students with an emphasis on creativity-oriented pedagogy and the quality of the physical learning environment the core conceptual foundations were first examined. Through content analysis and inductive reasoning, the conceptual structure was progressively refined, moving from macro-level theoretical perspectives toward micro-level constructs, ultimately integrating prior research and relevant theoretical frameworks. Based on this analytical process, a set of determinants was extracted as the primary factors to be evaluated in the subsequent fuzzy Delphi procedure. These selected factors were then assessed across three iterative Delphi rounds using expert questionnaires. The process led to the final identification of eleven indicators, which constitute the proposed framework for evaluating creativity in architectural education. These indicators have been organized into thematic and procedural categories within the research framework, as presented in Tab 7.

Table 7: Research Framework for the Final Indicator Model of Architectural Students' Creativity, Focusing on Creative-Based Pedagogy and the Quality of the Physical Learning Environment (Source: Authors)

Indicator Name	Qualitative	Indicator Type	Assessment Context	Assessment Method	Measured Metric
Group Participation	Qualitative	Process/Behavior	Observation of group processes	Questionnaire	Level of collaboration, active participation, fair division of tasks
Design Thin king	Qualitative	Process/Cognitive	Evaluation of problem-solving designs, design critique	nterview / Behavioral Assessment	Depth and coherence of spatial reasoning, openness to revision
Multisensory Spatial Representation	Qualitative	Representation/ Spatial Language	Review of diversity of representations, media coverage	Interview / Behavioral Test	Richness and multiplicity of representation tools, alignment with spatial concepts
Spatial Flexibility	Qualitative	Spatial/Applied	Usability testing, evaluation of spatial adaptability	Questionnaire	Adaptability of space for different uses and responsiveness to team needs
Effective Lighting and Acoustics	Qualitative/ Quantitative	Technical/Sensory	Measurement of lighting and sound levels, comfort evaluation	Questionnaire / Quantitative Analysis	Impact of light and sound on focus and spatial functionality
Accessibility	Qualitative/ Quantitative	Spatial/Political	Assessment of space accessibility, student interviews	Questionnaire / Quantitative Analysis	Ease of use and inclusivity for all students
Managerial Support	Qualitative	Organizational	Interviews with managers, documentation of support	Questionnaire	Presence of policies and resources supporting creative education
Digital Technologies	Quantitative/Qualitative	Tools/Process	Use of software, coverage of digital tools	Questionnaire / Quantitative Analysis	Scope and functionality of digital tools in the learning process
Representation Culture	Qualitative	Cultural/Cognitive	Group interviews, review of representation samples	Interview / Behavioral Test	Acceptance of diversity and multiplicity in spatial representation languages
Project-Based Learning	Qualitative	Process/Constructive	Evaluation of project process, periodic reviews	Questionnaire	Continuity of learning with architectural outputs and spatial representations

Communication Skills	Qualitative	Cognitive-Social	Assessment of presentations, peer evaluation	Questionnaire	Clarity of expression, quality of team and technical communication

Interpretation and Synthesis of Findings

Consequently, the findings reveal that group collaboration serves as the foundational indicator for establishing a cooperative climate within design teams. Its assessment—conducted through direct observation of group processes and levels of participation—provides a measurable understanding of students' active engagement throughout the design workflow. Given its role in creating a psychologically safe environment for idea expression, this indicator contributes to reducing fear of failure and increasing the willingness to explore alternative solutions, ultimately enhancing the quality of architectural outcomes. Design thinking, as the second indicator, foregrounds spatial reasoning, problem-solving, and conceptual flexibility. Through evaluative criteria such as depth of spatial argumentation and openness to iterative revisions, it becomes possible to assess the rigor of students' design processes. This shift from a mere production-oriented approach to an iterative, reflective one demonstrates how reinterpretation and revision can strengthen the architectural design output. The third indicator, multisensory spatial representation, evaluates the diversity of representational tools employed by students. It emphasizes that expanding the repertoire of representational media enhances spatial comprehension and, through increased exposure to multiple modes of expression, facilitates broader critique and reflection. Spatial flexibility, the fourth indicator, attends to the adaptability of learning and studio spaces. By employing usability testing and assessments of spatial reconfigurability, this indicator examines whether the physical environment can respond to team needs and contribute to more effective design processes.

Effective lighting and acoustics, the fifth indicator, underscore the influence of illumination quality and acoustic comfort on concentration and spatial representation. Objective measurements of lighting levels and sound conditions combined with subjective assessments of perceived comforthighlight how environmental variables shape deeper cognitive engagement and the precision of spatial representations. The sixth indicator, accessibility, ensures that learning spaces accommodate all students, thereby reducing both physical and cognitive barriers to participation. Evaluating accessibility yields insights into students' ease of navigation and their equal opportunity to engage with studio activities. Managerial support, as the seventh indicator, functions as a critical organizational element. It assesses the presence of institutional policies and resource infrastructures that enable the implementation of creativity-oriented pedagogy. Without adequate institutional backing, pedagogical reforms and spatial improvements face practical limitations. The eighth indicator, digital technologies, addresses the availability, diversity, and effectiveness of digital tools within the learning process. The integration of digital platforms broadens opportunities for visualization, collaborative ideation, and iterative spatial exploration. Narrative and representational culture, the ninth indicator, emphasizes students' acceptance of diverse architectural representation languages. Through focus-group interviews and analysis of representational artifacts, this indicator assesses how representational plurality enriches conceptual understanding and encourages the development of more nuanced spatial narratives. Project-based learning, the tenth indicator, demonstrates the alignment of learning processes with architectural outputs. By evaluating iterative project development and the evolution of spatial representations, this indicator affirms the role of project-based tasks in strengthening intrinsic motivation, design ownership, and architectural literacy. The eleventh indicator, communication skills, highlights the importance of articulation, clarity, and collaborative exchange in architectural learning. Through peer-review and presentation-based evaluations, this indicator measures students' verbal, auditory, and visual communication competencies. The ability to effectively convey design ideas to diverse audiences is accordingly recognized as a determinant of project performance and an essential component of creativity-oriented pedagogy. From a theoretical standpoint, the interrelations among these indicators suggest that group collaboration and design thinking mutually reinforce one another: active participation and constructive critique help cultivate nonlinear reasoning and spatial flexibility. Similarly, multisensory representation, combined with effective lighting and acoustics, contributes to enhanced spatial articulation and reduced environmental stressors, thereby improving cognitive immersion and deep learning. Furthermore, accessibility and managerial support create an inclusive and resource-rich environment that sustains creativity-driven learning. Digital technologies and representational culture expand expressive capacities and foster multidimensional critique. Project-based learning strengthens students' sense of authorship, while communication skills directly influence the clarity, coherence, and persuasiveness of architectural outcomes. In summary, the integrated application of these eleven indicators—refined through the fuzzy Delphi method—yields a comprehensive, dynamic, and sustainable framework for evaluating the factors that influence creativity among architecture students within creativity-oriented learning environments. This synthesis underscores that effective architectural education requires the alignment of three foundational dimensions:

•The design of physical learning spaces as catalysts for conceptual reasoning;

•Digital and representational capabilities that expand expressive potential; and

•Institutional support mechanisms that ensure pedagogical continuity.

Ultimately, the operationalization of these indicators in practice can lead to the development of architectural studios and classrooms that feature optimized physical environments, more creative learning processes, and higher-quality, innovative architectural outputs.

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