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RESEARCH ARTICLE

A Triangulated Inquiry into Computational Design Integration: proposing a Framework for Design Education Reform

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ABSTRACT

Architectural education in Pakistan is currently undergoing a pedagogical transformation that mirrors broader shifts in higher education across the Global South. This study explores how design learning is evolving from traditional, hand-based teaching toward digitally supported and process-oriented pedagogies. Using a Methodological Triangulation, a mixed-method approach, data were collected through three different methodologies, including a Google questionnaire, semi-structured interviews with faculty and students from architecture schools in Lahore, Karachi, and Islamabad, and a questionnaire with students after the studio conducted during the fall of 2023 at the Department of Architecture, University of Engineering and Technology Lahore. Thematic coding in NVivo yielded five interrelated domains: student learning, studio methodology, learning environment, teaching culture, and technology integration, through which the study maps critical transitions in educational practice. Findings reveal a complex landscape in which students advocate for experimentation, collaboration, and digital literacy, while many educators remain aligned with hierarchical and analog studio traditions. The gradual introduction of Computer-Aided Architectural Design (CAAD) has enhanced reflective thinking and interdisciplinary learning but has also exposed systemic gaps in curriculum design, institutional readiness, and teacher development. By situating these findings within contemporary discourses on digital pedagogy and decolonizing education, the study proposes a hybrid framework that links technological competence with contextual sensitivity and how digital adoption reshapes both cognitive and institutional dimensions of design education.

Contribution/Originality: This study contributes to the existing literature by identifying innovative strategies and proposing new pathways for architectural studio education in Pakistan. It develops a context-specific framework guiding digital pedagogy, supports practice-driven and research-based studios, documents emerging

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methodologies and challenges, promotes experimentation with digital approaches, and serves as a reference base for future academic and professional growth.

1. Introduction

Architectural education has long relied on the studio as its epistemic core, a space of discovery, critique, and apprenticeship (Ceylan et al., 2024; Repon et al., 2021). Within the Pakistani context, this studio culture has largely mirrored the Beaux-Arts and modernist traditions inherited from colonial educational systems, emphasizing master-apprentice learning, manual drafting, and visual mimicry. However, the global proliferation of digital technologies, including Computer-Aided Architectural Design (CAAD), parametric modeling, and algorithmic workflows, has unsettled these traditions, provoking what Oxman (2008) termed the digital design paradigm (Oxman, 2018) The conversation around the pros and cons of using digital tools in architectural design studios is still ongoing (Ceylan et al., 2024). What many agree on, though, is that the most successful outcomes often come from striking a balance between traditional methods and digital technologies. Even so, it is clear that digital tools are playing an increasingly important role in design studios as their use continues to grow. One major driver of this trend is the rapid advancement of information and communication technologies (ICT) tailored to architectural needs (Papamanolis et al., 2018). In Pakistan, however, this digital turn remains uneven. While international schools increasingly embed coding, simulation, and digital fabrication within their core curricula (Kalay, 2019)Local institutions struggle with infrastructural constraints, outdated syllabi, and limited faculty competence (Asghar, 2025). The result is a pedagogical dissonance: students encounter digital media as presentation tools rather than as cognitive instruments for design reasoning(Oxman, 2008). This disconnect threatens to marginalize Pakistani graduates within a rapidly digitizing profession while reinforcing outdated pedagogical hierarchies that privilege analog skill over digital literacy.

Despite the widespread recognition of digital technologies, the transformative potential and its integration into Pakistani architectural studios remain fragmented (Asghar, 2025; Masood et al., 2014). Technology is often introduced in upper-year courses as elective software training rather than as a conceptual extension of design thinking. Faculty hesitance, regulatory rigidity from bodies such as PCATP and HEC, and limited access to resources further exacerbate this lag. Consequently, architecture students experience a learning environment caught “between hand and algorithm” where the rhetoric of innovation coexists with entrenched pedagogical conservatism.This study responds to this challenge by using a methodological triangulation approach, which can help understand the challenging architecture scenario in Pakistan through three different perspectives to gain better insight into the issue. It seeks to uncover how educators and students negotiate this transition, what obstacles persist, and what frameworks might enable an inclusive, future-oriented studio culture.

1.1. Research Objectives

The overarching aim is to critically analyze the integration of CAAD into Pakistani architectural studios using three methods, including quantitative survey, qualitative interviews, and a studio study analysis. Then, using the triangulation method, which combines all three methods, we can formulate a hybrid pedagogical framework responsive to local contexts. The study addresses the following research questions:

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i. How do architecture faculty and students in Pakistan perceive the role of CAAD in shaping studio education?
ii. What transformations in studio methodology, environment, and teaching culture accompany this paradigm shift in Pakistan.
iii. How can a hybrid framework reconcile manual and computational approaches to produce contextually relevant digital pedagogy in Pakistan.

The literature review establishes a comprehensive, multi-layered theoretical framework crucial for analyzing architectural education, particularly in Pakistan. The first two concepts, Schön's reflective practitioner and Oxman's digital morphogenesis, anchor the study within the contemporary global discourse on design cognition and computational practice (Schön, 2017; Oxman, 2008). They define digital tools not as mere drafting aids, but as cognitive mediators that facilitate real-time reflection-in-action and a shift toward generative, data-driven design. However, the third concept, Post-colonial and Contextual Pedagogy, acts as the vital critical lens for the entire study (Nilufar et, al., 2012). By arguing against the uncritical transfer of Western pedagogical models, this literature directly links the abstract, universal ideals of digital design (reflection and generation) to the local, socio-technical realities of the Global South. The core function of this literature review is thus to set up a powerful tension: it leverages the aspirational goals of advanced digital practice while simultaneously demanding their implementation in Pakistani architectural education.

2. Literature Review

The 21st century has seen a dramatic transformation in architecture, mainly driven by the integration of digital technologies. What began as tools to enhance traditional workflows, such as computer-aided architectural design (CAAD), digital collaboration platforms, and virtual modeling, has now grown into a fundamental redefinition of architectural practice (Kalay, 2019). These tools initially helped streamline specific tasks such as rendering and traffic modeling. However, over time, they have become essential platforms for conceptualizing complex, environmentally responsive, and sustainable designs(Gül et al., 2007). One of the most significant impacts of digital tools is that these enforces collaboration in architecture studio and otherwise. All the stakeholders in architecture can contribute to the design process in real time. This integrated communication not only improves efficiency but also fosters innovation, producing architectural outcomes that are more creative, responsive, and refined (Holzer et al., 2007; Kalay, 2019). Traditional pedagogy has long relied on hierarchical systems, emphasizing mastery of hand-drawing, stylistic replication, and formal aesthetics (Salama, 1995). While this method has been successful in developing technically competent architects, it often fails to prepare students for the rapidly evolving demands of the profession, particularly in areas like sustainability, equity, and digital literacy (Ceylan et al., 2024;Asghar, 2024). As educational paradigms shift, there is increasing recognition of the value digital tools bring to architectural studios. Research by Ceylan (2024) shows that students benefit from digital tools not only for visualizing ideas but also for developing and iterating designs(Ceylan et al., 2024). Technologies such as parametric modeling, evolutionary structural optimization (ESO), material computation, and artificial intelligence are now central to both design exploration and performance analysis (Penttilä, 2022).

Interestingly, the digital concepts shaping today's practice are not entirely new (Schön, 2017). Thought leaders from the 1960s, including Leslie Martin, Lionel March, Frei Otto,

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Archigram, and Cedric Price, laid the theoretical groundwork for what would become digital architecture. Their ideas, particularly around mathematical form, structural optimization, and speculative urbanism, influenced a generation of innovative architects such as Richard Rogers, Daniel Libeskind, Norman Foster, Frank Gehry, and Zaha Hadid (Kim et al., 2022). Kim and Jeon (2022) classify the intellectual evolution of digital design into three lenses: Mathematics and Function, Nature and Structure, and Imagination and Form. These frameworks provide a way to trace the lineage of parametric design, a now-critical approach in architectural education and practice (Kim et al., 2022).

The studio-based learning model remains at the heart of architectural education (Repon et al., 2021) . Despite its enduring value, there's growing concern that studio culture can be overly focused on aesthetics and form, at the expense of theory, method, and inclusivity. Many studios still prioritize visual output over conceptual depth, sidelining talented students who may not conform to conventional creative norms (Schwennsen et al.,2002; Ceylan et al., 2024). In South Asia, particularly Pakistan and India, resistance to digital transformation in architectural education is significant. Asghar (Asghar et al., 2025; points out that many educators remain reluctant to embrace digital tools due to either a lack of exposure or an ingrained fear of technology.

In India the situation is quite similar in a way that, architecture education typically begins with a focus on traditional methods like hand-drawing and physical model-making. While digital tools are introduced later in the curriculum (usually by the third year), the transition is often poorly managed (Dua et al., 2014; Sheweta et al., 2016). This creates a disjointed learning experience, where students struggle to integrate both skill sets (Memon, 2007) effectively. Dua and Chahal (2014) argue that India's curriculum also relies heavily on Western research, with limited emphasis on indigenous scholarship. There's a pressing need for localized, visionary education one that balances craft, creativity, and contextual awareness (Dua et, al., 2014; Masood et al., 2014). Saxena Sheweta et al. (2016) support this view, emphasizing the importance of peer interaction, interdisciplinary collaboration, and attention to detail in construction and materiality (Sheweta et al., 2016). Iqbal, in her research on architecture student psychology and habitus (Iqbal et al., 2023) recommend updating pedagogical strategies to close the gap between traditional studio models and the realities of modern design. Their research suggests that studios should become more collaborative and digitally integrated to reflect real-world workflows. Xiang (2020) explores how architectural education can move beyond teaching software through various frameworks for universities in china. He argues that educators must cultivate *design thinking* through digital tools. encouraging students not only to use technology but to think critically about how it shapes the design process(Repon et al., 2021; Xiang et al., 2020). While digital technologies offer exciting possibilities, several researchers have warned against over-reliance on them. Guney (2015) cautions that students who depend too heavily on computer-aided design (CAAD) may struggle to develop original, creative ideas(Guney, 2015). In contrast, Salman et al. (as cited in Achten, 2003) see digital tools as helpful during the early stages of design exploration (Henri H., 2003; Salman et al., 2007). Breen (Gulay, 2020) proposes a balanced, hybrid approach that combines digital and physical methods. He believes that the tactile experience of sketching and model-making provides designers with a more grounded understanding of form and space, something that purely digital approaches can miss. Al Matarneh and Fethi (2017) agree, arguing that both modes of design should be embedded in educational programs. They stress

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that digital innovation should enhance, not replace, the creative intuition that emerges from hand-drawing and physical prototyping (Al-Matarneh et al., 2017; Gulay, 2020).

Architecture today stands at the crossroads of tradition and transformation (Reffat, 2006). While digital technologies have revolutionized design processes and collaboration, their integration into architectural education remains uneven. The studio method, still the bedrock of architectural pedagogy, must evolve to reflect the realities of contemporary practice (Kuhn, 2001; Reffat et al., 2006). This includes embracing digital innovation, promoting interdisciplinary collaboration, valuing local contexts, and preparing students not just to design, but to think critically and ethically. For countries like Pakistan, the path forward requires bold curricular reform, technological investment, and a willingness to shift educational cultures. Educators must create learning environments that blend analog and digital, theory and practice, individual creativity and collective responsibility (Asghar et al., 2025).

3. Methodology

The research design of this study adopts a triangulated mixed-method approach to address the complexity of computational design integration in architectural education. This design is justified because the phenomenon under investigation involves multiple stakeholders (students, faculty, institutions) and layered pedagogical dynamics that cannot be captured through a single method.Firstly, a quantitative survey (Google questionnaire) was used to gather broad, generalizable insights from a larger student population. This method is justified as it enables the identification of trends, patterns, and overall perceptions regarding CAAD integration across different institutions.

Secondly, semi-structured interviews with faculty and students were conducted to obtain in-depth qualitative insights. This method is appropriate because it allows participants to express nuanced experiences, attitudes, and challenges, which are essential for understanding the underlying pedagogical and cultural dynamics influencing digital adoption.

Thirdly, a studio-based post-intervention questionnaire and analysis was included to capture real-time reflections from students engaged in an actual design studio. This is justified as it links perceptions with practice, enabling the study to move beyond opinions toward lived educational experiences.Lastly, thematic analysis using NVivo was employed to systematically interpret qualitative data. This method is justified as it allows for rigorous coding, pattern identification, and the development of coherent themes, ensuring analytical depth and validity.

Overall, the use of methodological triangulation strengthens the reliability and validity of the research by cross-verifying findings across multiple data sources and methods, providing a holistic and well-substantiated understanding of the research problem

Earlier scholarships have investigated different pedagogical approaches, assessment methods, and the role of technology in the studio environment, examining the effectiveness of teaching strategies like project-based learning, collaborative design, and interdisciplinary approaches. Investigating the specific ways emerging technologies, including digital tools, CAAD, and simulations, are used in design studios and their influence on the learning process has to be explored in Pakistan. The literature review suggests a significant gap in understanding how integrating emerging technologies, such

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as CAAD, can be seamlessly incorporated into the architecture studio pedagogy to enhance student learning and design outcomes in resource-constrained environments like Pakistan.

The study population comprised both architecture students and faculty (academicians) from accredited architecture schools in Pakistan. Participants were drawn from three major cities:Lahore, Karachi, and Islamabad, selected due to their relatively higher technological engagement in architectural education

The sample size for the questionnaire was calculated step-by-step. The target participants were architecture students and academicians in architecture schools in Pakistan, and the survey targeted architecture students in the fourth and fifth years of architecture programs across Pakistan. According to the PCATP's latest data report, 55% of registered architects in Pakistan are academicians, totaling 3,733. Of these, 24% are academicians, resulting in 1,642. While we don't have an exact date for academicians in each school due to variations, we assume a significant portion. Approximately 50% of these academicians are based in Lahore, Karachi, and Islamabad, given that these are the major urban centers.

Academicians Estimate: 50% of 1,642 = 821 (approximate).

Known Variables
1. Population Size (N):
   - 4^{th}/5th-year Architecture Students: 2,500
   - Academicians across all schools Estimated at 821
   - Combined population = 2,500+821=3,321
2. Confidence Level (Z): 95% (Z = 1.96)
3. Margin of Error (E): 5% (E = 0.05)
4. Estimated Proportion (p): 0.5 (used for maximum variability)

Sample Size Formula
For a finite population, the sample size is calculated using the formula:

$$n = \frac{N \cdot Z^2 \cdot p \cdot (1-p)}{E^2 \cdot (N-1) + Z^2 \cdot p \cdot (1-p)}$$

Step-by-Step Calculation

Step 1: Calculate Components
1. $Z^2 = 1.96^2 = 3.8416$
2. $p \times (1 - p) = 0.5 \times 0.5 = 0.25$
3. $E^2 = 0.05^2 = 0.0025$

Step 2: Calculate Numerator and Denominator
Numerator:
$N \times Z^2 \times p \times (1 - p) = 3,321 \times 3.8416 \times 0.25 = 3,184.8$
Denominator:
$E^2 \times (N - 1) + Z^2 \times p \times (1 - p) = 0.0025 \times 3,320 + 0.9604 = 8.3 + 0.9604 = 9.2604$
Step 3: Calculate Sample Size
n = Numerator / Denominator
$n = 3,184.8 / 9.2604 \approx 344$

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The required sample size for the survey is approximately 344 participants. This ensures a representative sample with a 95% confidence level and a 5% margin of error.

For the quantitative component, random sampling was used to distribute questionnaires among architecture students and academicians across multiple institutions, ensuring broader representation and generalizability of findings.

For the qualitative component, purposive (selective) sampling was adopted to identify participants with relevant experience and varying exposure to digital and traditional design methods, enabling in-depth exploration of perspectives. In the studio-based study, all ten participating students were included.

Data were collected using a mixed-method approach, combining questionnaires, semi-structured interviews, and a studio-based study. Semi-structured interviews were used as the primary qualitative method, allowing flexibility and deeper exploration of participants' experiences and perspectives. These interviews were conducted with selected students and faculty, recorded for accuracy, and later analyzed through thematic analysis.

The communication medium is not explicitly limited but includes both in-person and contextual studio-based interactions, particularly in the studio study conducted at the University of Engineering and Technology, Lahore. Interviews typically followed a guided but flexible format, enabling participants to elaborate on their experiences. Additionally, quantitative data were collected through Google-based questionnaires and then data is analyzed in SPSS. This ensured continuous and comprehensive data capture throughout the study

The study employed both quantitative and qualitative data analysis techniques in line with its mixed-method research design. Quantitative data obtained from the questionnaire (n=265) were analyzed using SPSS (Statistical Package for Social Sciences). Cross-tabulation was applied to compare responses across different participant groups, enabling the identification of patterns, trends, and variations in perceptions regarding digital and traditional design approaches. For qualitative data, thematic analysis was conducted, and 30 academics and 30 students from schools across Pakistan were interviewed via semi-structured interviews. The data were systematically coded and analyzed using NVivo 14, allowing the identification of recurring patterns, themes, and relationships within participants' experiences and viewpoints. This process provided a rich, contextual understanding of the research problem. The integration of both datasets was achieved through methodological triangulation, enhancing the validity and reliability of findings by cross-verifying insights from multiple sources and analytical techniques

Ethical approval for this study was obtained from the Department of Architecture University of Engineering and Technology Lahore. All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research committee.

Informed consent was obtained from all participants prior to data collection, and participation was voluntary. Consent was documented through agreement to participate in questionnaires and recorded interviews, with assurances of confidentiality and anonymity maintained throughout the study.

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4. Findings

4.1. Analytical Findings

For qualitative research, a total of sixty semi-structured interviews were conducted between 2023 and 2024 with architecture students and faculty from ten accredited institutions in Lahore, Karachi, and Islamabad. Participants were selected through purposive sampling to represent varying levels of exposure to digital tools, from schools with emerging CAAD curricula to those reliant on traditional design instruction. Each interview lasted 30–45 minutes and followed a guided protocol addressing participants' experiences, attitudes, and perceived challenges.The interviews were transcribed and analyzed using NVivo 14, following (Naeem et al., 2023)six-phase thematic approach: familiarization, initial coding, theme generation, theme review, naming, and synthesis. Coding categories were aligned with the study's guiding questions and refined through iterative comparison. Thematic matrices and triangulation charts cross-compared faculty and student responses, revealing convergences and divergences in perception. The analytical process emphasized pattern matching and theoretical saturation, ensuring each theme connected empirical evidence with conceptual interpretation.

This study applies two complementary interpretive frameworks to examine digital integration in architectural education. First, *Constructivist Pedagogy:* positions design learning as a socially constructed process where meaning is formed through dialogue, experimentation, and reflective practice. Second, *Socio-technical Systems:* Theory conceptualizes the architecture studio as a dynamic ecosystem shaped by the interplay between human agency, institutional policies, and digital infrastructures. Aligning the study's findings with these frameworks reveals that digital adoption is transforming students' cognitive engagement with design and reshaping the institutional structures that govern teaching practices. To ensure robust interpretation, the study employs a triangulation method, using themes generated through NVivo 14. This includes three levels of research (Table 1): methodological**,** combining student interviews, questionnaires, and design studio assessments; data source, capturing insights from both faculty and students across multiple architecture schools in Pakistan; and theoretical, linking empirical evidence to foundational theories in pedagogy and technology. The convergence of these approaches enhances the study's validity, moving beyond descriptive observations to more meaningful interpretive generalizations.

Table 1: Analytical Framework for the research (Author)

Component	Description
Interpretive Framework 1	Constructivist Pedagogy – Learning through social interaction, experimentation, and reflection.
Interpretive Framework 2	Socio-technical Systems Theory – Design studios as dynamic systems of people, policy, and tech.
Analytical Focus	Mapping how digital tools affect both cognition (learning) and institutional teaching structures.
Triangulation Type	1. Methodological – Interviews, questionnaires, and studio reflections.
	2. Data Source – Perspectives from both students and faculty across Pakistan.
	3. Theoretical – Linking data to educational and technological theories.

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Component	Description
Outcome	Validated findings with interpretive generalizations, not just descriptive reporting.

4.2. Analytical Findings

The thematic analysis generated five intersecting domains of insight that collectively illustrate the transitional dynamics of architectural pedagogy in Pakistan. These themes include Impact on Student Learning, Studio Design Methodology, Studio Environment, Studio Teaching Methods, and Technology Integration, highlighting the frictions and synergies between manual and digital modes of studio practice. Each is discussed below as a critical lens through which CAAD's role in reconfiguring studio learning is interpreted.

4.3. Impact on Student Learning

The Triangulation chart (Table 2) revealed that when inquired, both students and educators recognize CAAD's potential to enhance critical thinking, collaboration, and design experimentation**,** yet they differ in their understanding of how these outcomes materialize. Faculty members frequently described CAAD as a *representation tool*, while students regarded it as a *thinking process*. This divergence underscores a fundamental pedagogical gap: teachers often associate digital tools with post-design documentation, whereas students experience them as generative instruments that transform cognition and creativity. A majority of participants acknowledged through all their methods that exposure to CAAD encourages analytical thinking through iterative visualization and simulation. However, some faculty remained skeptical, arguing that students rely too heavily on automation and neglect conceptual development. This tension reflects Schön's (1983) distinction between *reflection-in-action* and *reflection-on-action*: digital workflows may enhance the former by enabling instant feedback loops but can weaken the latter if unaccompanied by theoretical reflection. Empirical data suggest that when CAAD is integrated from early academic stages, students demonstrate enhanced spatial reasoning and problem-solving skills. Yet, in Pakistan's current system, where CAAD instruction often begins in the third year, critical engagement emerges too late to reshape foundational design thinking. Thus, the delayed induction of digital tools perpetuates cognitive fragmentation between analog ideation and digital execution.Students who had participated in digitally driven studios frequently emphasized interdisciplinary exposure, citing collaborations with peers in computer science, visual arts, and engineering. This aligns with global literature arguing that CAAD can foster a networked studio culture (Wang et al., 2012) where design problems are approached holistically. Nevertheless, most Pakistani faculty reported minimal institutional support for such collaborations, with CAAD confined to isolated computer labs.

Students advocated for *learning by doing* through visual programming and digital fabrication, interpreting these activities not as technical training but as new epistemologies of design. The evidence suggests that CAAD's influence on student learning extends beyond software proficiency; it redefines design as a process of computational reasoning and material experimentation, demanding a pedagogical paradigm that privileges iterative engagement over static critique

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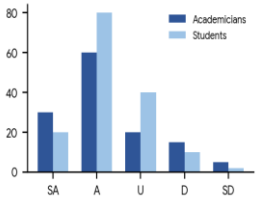
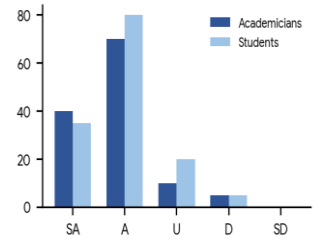
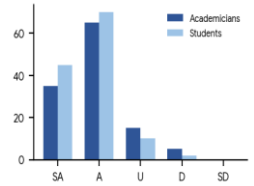
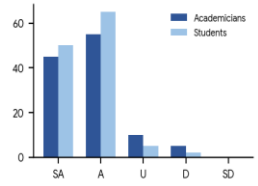
Table 2: Triangulation Chart on Impact on Studio Learning

Themes Generated	Enhances Critical Thinking	Interdisciplinary	Process Oriented	Shift to tools and Technology	Visual Programming	Hands on Learning
Quantitative Research: Google questionnaire was designed for Architecture Faculty and Students from three cities in Pakistan 265 Responses were collected	 The majority in both groups responded "Agree" or "Strongly Agree," showing that this is the general consensus of how well CAAD develops certain abilities. There are, however, some individuals who are unsure or disagree, showing varied viewpoints on how well CAAD			 The opinions from academics and students regarding the value of computer-aided architectural design (CAAD) tools in improving comprehension of context and spatial planning are shown in the table. A sizable majority in both groups responded "Agree" or "Strongly Agree," demonstrating broad agreement that CAAD tools promote proper comprehension. Although there are some respondents who are unsure or disagreeing, indicating different points of view, the overall trend shows that CAAD tools have a beneficial effect on improving spatial comprehension and contextual knowledge for both Academicians and Students.	 Responses from academics and students are shown in the table indicating how well visual programming tools can make difficult analyses simpler. The majority in both groups responded "Agree" or "Strongly Agree," showing that there is broad agreement that these tools make complex studies easier.	 Responses from academics and students towards integrating self-regulated learning in the digital age are shown in the table. The majority of respondents in both categories indicate that they "Agree" or "Strongly Agree," which indicates that the viewpoint is broadly supported. Few replies were disagreed with, and there were a few that were unsure, which points to a general favorable attitude towards include self-regulated learning techniques in the digital educational scene.

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Qualitative Research Semi-Structured 60 Semi-structured Interviews were Conducted Architecture Faculty and Students from	Academicians are not very sure that whether the use of digital tools enhances critical thinking. Students also have mixed reviews about the enhancement of critical thinking amongst students due to the use of Digital and CAAD tools to design.	A very small majority of the teachers have mentioned that interdisciplinary education should be introduced with the help of tools. Students have not talked much about interdisciplinary interactions, indicating they either haven't experienced them.	Shift of focus from End Product to Process-oriented pedagogy is discussed by the majority of academics, and they have spoken in favor of that in their interviews. Students have mixed opinions about the shift of focus from end product to process-oriented pedagogy.	Majority of the academicians wants to switch to adopting digital tools and technology making it the largest box in the hericchy. This suggests a focus on how digital tools and technology are being integrated into studio learning environments.	Academicians didnt talked much about visual programming as an essentail part of the curriculum. On contrary to these students feel that it is important for visual programming to become the part of the curriculum. The biggest domain on which students want to indulge.	The study indicates that Academicians are open to discuss hands on learning. This seems to be truncated but may imply a shift in educational emphasis, possibly towards more practical skills. Students wants to experience more jand on learning and that is possible with the use of tools and technology. This also indicates interest in fabrication using digital tools.
Studio Interviews Results: 10 semi-structured Interviews	Studio students also have mixed reviews about the critical thinking enhancement with the tools.	This category emphasizes the importance of cross-disciplinary engagement. Students who prefer this approach likely value collaboration across different fields. It encourages interactions between students from diverse backgrounds, fostering creativity and a holistic understanding of complex problems.	No student talked about process-oriented design in the studio.	This suggests a focus on how digital tools and technology are being integrated into studio learning environments.	Positioned at the bottom right, this implies that the study also considers the benefits of visual programming as a part of the curriculum.	This reflects an experiential learning approach where students learn through engagement and hands-on activities in the studio, and students are eager to adopt it in the studio.

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4.4. Studio Design Methodology

It can be seen as presented in (Table3) that Digital introduction challenges the methodological orthodoxy of Pakistani design studios, which traditionally privilege aesthetic outcomes over process-based inquiry. The triangulated data reveal increasing consensus among students and some faculty for a hybrid pedagogical model that merges manual exploration with computational logic.

Most participants endorsed a hybrid design methodology, advocating for hand sketching and algorithmic modeling to coexist rather than compete. This perspective echoes (Lockwood et al., 2018) argument that design thinking thrives on oscillation between intuition and analysis. In hybrid studios, CAAD serves as an intermediary translating analog ideas into computational parameters and vice versa.

Yet, institutional inertia often constrains this hybridity. Many schools still assess student work based on final renderings rather than the iterative processes underlying them. The result is what (Oxman, 2003)calls the representation trap a fixation on visual polish that obscures the cognitive potential of computation. The study finds that students exposed to process-based evaluation developed stronger analytical and self-assessment skills, supporting calls for curriculum reforms emphasizing design process literacy. A notable finding concerns the deficiency of geometric and mathematical training in local curricula, which limits students' capacity to engage meaningfully with parametric tools such as Grasshopper or Revit Dynamo. Faculty members admitted that mathematics is often treated as peripheral to design education. This gap undermines students' ability to understand algorithmic relationships between form and data, restricting CAAD to superficial visualization.

Participants recommended the inclusion of theory courses on computational logic and algorithmic geometry, suggesting that mathematical reasoning should be positioned as a design skill rather than a technical prerequisite. Such integration would align Pakistan's studios with international pedagogical movements emphasizing digital craft Experimentation and Early Exposure (Gulay, 2020). Across institutions, students expressed frustration with limited opportunities to experiment with digital media. Faculty apprehensions, often rooted in their own lack of CAAD expertise, translate into restrictive studio guidelines that discourage risk-taking. The analysis reveals a cyclical dynamic: teachers' digital insecurity leads to curricular rigidity, which in turn suppresses students' creative exploration.

Conversely, studios where CAAD was introduced from the first year demonstrated greater adaptability and conceptual fluency. Participants advocated for scaffolded digital exposure, beginning with conceptual visualization tools in the foundation year and advancing toward parametric modeling in later stages.

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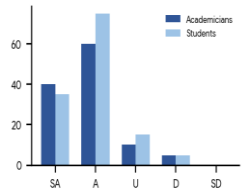
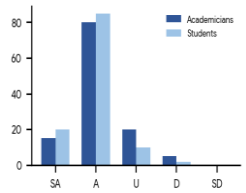
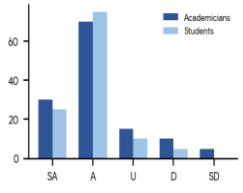
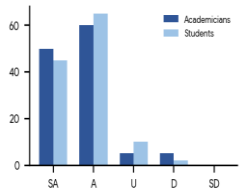
Table 3: Triangulation Chart on Studio Design Methodology (Author)

Themes Generated	Hybrid Methodology for Teaching	Teachers Studio Methodology	Technology Integration at the basic level	Multidisciplinary Studio education	Grip over Geometry and Mathematics	Room for Experimentations	Addition of Theory Subjects
Quantitative Research: The Google questionnaire was designed for Architecture Faculty and Students from three cities in Pakistan .265 Responses were collected	 In both groups, the majority responded "Agree" or "Strongly Agree," demonstrating a general consensus about the necessity of changing educational frameworks to accommodate CAAD. The few conflicts and replies that aren't sure highlight the consensus that CAAD should have a big say in how architecture education is changed.	 With the majority of respondents in both categories selecting "Agree" or "Strongly Agree," there is a solid consensus that cognitive problems should be incorporated into the results of digital education. The general acceptability of this strategy is highlighted by the lack of objections and ambiguous replies, highlighting the significance of including cognitive problems in digital education inside studio.	 A sizable majority in both groups responded "Agree" or "Strongly Agree," underscoring the general view that the lack of understanding is the main reason why CAAD is still new. There are some people who are unsure or disagreeing, highlighting the need for further education and understanding in this area.	 Both groups had a sizable majority that responded "Agree" or "Strongly Agree," highlighting the general agreement that experiential learning should be used. There aren't many objections, which suggests that this hands-on learning strategy is widely favored.		Students should be provided prior CAAD knowledge for them to perform better in studio. No one talk about supportive theory subjects in this domain	

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Qualitative Research Semi-Structured 60 Semi-structured Interviews were Conducted Architecture Faculty and Students from three cities in Pakistan.	Academicians are supporting a hybrid Methodology of teaching in studios, especially for Pakistan, but some of them also prefer to have Pre Requisites for entering into the Architectural Schools. The majority of the students, when inquired about the use of technology, preferred the hybrid methodology of teaching in Pakistani Studios.	None of the academics discussed the teachers' studio Methodology and how it needs to be changed. Majority of students believed that there should be a transformation of teaching and learning in studios to accommodate Tools and Technology.	The majority of the academicians believe that Advanced Technology should be integrated at the basic level to make the transition easier The majority of the students in Pakistan still don't have a clear understanding of CAAD. Although they were very inclined towards the use of tools but intimidated as well. They demanded prior understanding of CAAD for the studio.	The majority of academicians are supportive of Multidisciplinary education and approve of the transformation of teaching and learning in studio Education because of the rapid change in Technology. Some students talk positively about the multidisciplinary education on studio including the teaching of mathematics and geometry.	Academicians have highlighted the importance of mathematics and Geometry for the Studio Training in future. Some students talk positively about the multidisciplinary education in the studio, including the teaching of mathematics and geometry.	Academicians believe, very few of them that students should be given room for experimentation in studio and should be allowed to explore new ideas and software. Students want to experience new software and techniques in the studio, yet there are lots of limitations of grading and the conventional system that has been followed in Pakistani Schools.	The hierarchy box at the lower right corner indicates that additional theory subjects linked to the digital techniques should be taught for better understanding .
Studio Interviews Results: 10 semi-structured Interviews were conducted with the students of the experimental studio	Strongly belcive in changing and transforming the studio teaching methods that they are currently pursuing in Studio but majority still prefers Hybrid methods.	No student talked about Teachers studio methodologies and how they need to be changed.	Strongly believes in the intervention of Technology at the basic level strating from first year or beyond.	Supports different interventions in different domains and indicates to have choices to study different domains during the five years of education.	Positioned at the bottom right, this implies that the students consider adding geometry and mathematic knowledge as a plus for advance studio learning.	This reflects and supports an experiential learning approach where students can experiment in studio and explore new horizons.	Additional digital based theory subjects will help support the Studio learning.

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4.5. Studio Environment

The third theme shown in Table 4, the physical and cultural environments of architectural studios, emerged as critical determinants of digital adoption. Traditional studio setups in Pakistan continue to resemble 20th-century ateliers, hierarchical, paper-based, and spatially inflexible. At certain institutes, the furniture and layout have not been changed since 2000. Students across all cities highlighted the absence of dedicated digital laboratories and interdisciplinary hubs. Faculty concurred at the minimal level, acknowledging infrastructural deficiencies, including inadequate computers, software licensing, and unreliable internet connectivity. This lack of digital infrastructure reinforces a segregated learning environment where analog and digital domains coexist but rarely intersect. Interest in virtual design studios (VDS) gained momentum during the COVID-19 pandemic. However, most participants noted that these experiences remained technologically shallow, limited to screen sharing rather than immersive digital collaboration, and have not been adopted as they should have been. Students expressed enthusiasm for future hybrid models integrating AR/VR, cloud-based modeling, and international peer exchanges. However, faculty emphasized contextual barriers, including inconsistent electricity supply, limited institutional bandwidth, and low digital literacy. The data suggest that while students envision the studio as an interactive digital ecosystem, faculty remain concerned with infrastructural feasibility.

4.6. Studio Teaching Methods

The triangulation chart in Table 5 depicts that Pedagogical resistance emerged as one of the most significant obstacles to CAAD integration. While institutional constraints are tangible, the ideological inertia within faculty culture, shaped by decades of manual training, represents a deeper barrier.Most of the faculty members confessed adherence to the “charrette model,” in which design instruction revolves around end-of-semester intensives that emphasize output rather than process. This model, though historically significant, discourages experimentation and fosters dependence on mentor approval. The study reveals that hierarchical teaching structures are incompatible with digital learning**,** which thrives on decentralization and iterative exploration. Students repeatedly cited teacher control as a demotivating factor, describing studios as spaces of compliance rather than curiosity. Conversely, younger faculty members advocated co-learning, positioning themselves as facilitators rather than gatekeepers, a shift aligned with constructivist pedagogy. These emergent practices signal a generational divide within architectural education: one anchored in drafting boards, the other in data-driven design environments. The debate over hand sketching versus digital sketching epitomizes this generational tension. Senior educators perceive hand drawing as the foundation of design intuition and spatial empathy, whereas students view digital sketching as an equally valid expressive medium. The analysis suggests that both views are not mutually exclusive. Instead, hybrid fluency, the ability to oscillate between tactile and digital modes, is increasingly vital.

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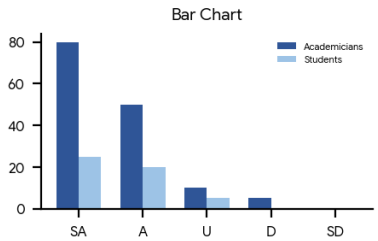
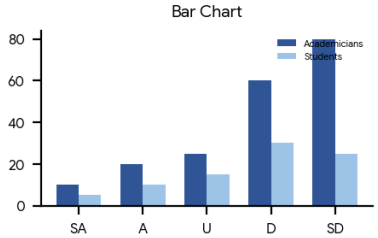
Table 4: Triangulation depicting results of Theme III-Studio Environment (Author)

Themes Generated	Collaborative Studios	Lab and Digital Studio Culture	Tech Oriented Studio Environment	Virtual Design Studios for Better Learning
Quantitive Research: Google questionnaire was designed Architecture Faculty and Students from three cities in Pakistan .265 Responses were collected	This discussion was generated during the semi-structured interviews.	 The bar chart is highlighting the majority of the academicians are endorsing the lab culture in the architecture schools comparatively a lesser percentage of students are also agreeing to this.	 Majority of the academicians disagreed with the idea of paper less studio. Students are also not very inclined towards the initiation of paper less studios.	
Qualitative Research Semi-Structured Interviews: 60 Semi-structured Interviews were Conducted Architecture Faculty and Students from three cities in Pakistan. Analyzed in NVivo 12	Most of the participants are in favor of designing collaborative spaces in studios as this helps in hands on experiences. The studios should be designed to have collaborative spaces, which are required for peer learning and hands-on experiences. The lower left square highlights the number of students who discussed collaborative spaces in the studio, but it seems that they haven't experienced such spaces so far.	The lower corner square is indicating that Academicians are inclined towards developing lab and digital studios culture in architecture school which is currently missing in majority school. The upper right rectangle in the corner indicates that students want to shift to the lab digital studio culture in their schools, which is currently missing.	Upper left corner in this hierarchy chart indicates that Academicians are discussing to the tech-oriented studios but the major hindrance is the affordability of software and gadgets that are required to make the studio environment tech-oriented Students have discussed the need to have a technology-oriented studio environment that includes a virtual-equipped environment and screens in the studio.	The upper right corner has the majority of academicians agreeing to have virtual design studios to enhance learning and teaching in architecture. Majority of students have supported virtually design studios to be used for better collaboration and learning. The bigger square on the upper left corner indicates its demand amongs students.
Studio Interviews Results 10 semi-structured Interviews were conducted with the students of the experimental studio.	The upper right corner of this chart indicates that the students are inclined to have collaborative spaces in the studio.	The lower box in the right corner indicates that students do need a lab and digital studio culture in their department, although the percentage of emphasis is not very high.	These studio students are inclined towards having tech-oriented studio environments. The lower left rectangle indicates the inclination.	The biggest box on this chart indicates the strong inclination towards the virtual design studios to be implemented in the studio teaching and learning process.

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Participants from digitally active studios reported that integrating research-based learning where design problems evolve from empirical data and computational testing significantly enhances their engagement and challenges them. However, these methods are hardly practiced. Faculty pointed out that regulatory bodies emphasize static curricula, limiting pedagogical experimentation. The study suggests that formalizing research-driven studios could bridge academia and industry while aligning local pedagogy with global shifts toward evidence-based design. Both groups highlighted the need for faculty development programs and regular workshops to overcome digital illiteracy. Students noted that their teachers' discomfort with technology often translated into outdated instruction. Periodic retraining, peer mentoring, and cross-institutional collaborations were proposed as means to cultivate a culture of continuous learning.

4.7. Technology Integration and Institutional Challenges

The triangulation chart in Table 6 depicts that all three methods suggest that the integration of CAAD exposes structural contradictions within architectural academia in Pakistan at the systemic level. Institutions aspire to digital modernization but lack the curricular agility, faculty capacity, and resource infrastructure required to sustain it. Both educators and students acknowledged a pervasive lack of understanding of CAAD's conceptual foundations. The software is often taught in isolation from design courses, producing technically skilled but pedagogically disconnected learners. This segmentation reflects an epistemological problem**,** treating technology as additive rather than integrative also discussed in earlier research (Gulay, 2020; Repon et al., 2021).Participants also highlighted infrastructural disparities between private and public schools. While private universities invest in digital labs and licensed software, public institutions rely on outdated hardware and informal workarounds. Such inequities perpetuate a digital divide that mirrors broader socioeconomic stratifications within higher education. A noticeable, recurrent theme was faculty reluctance rooted in job insecurity and fear of obsolescence. Senior academics perceive CAAD as a threat to their established expertise, leading to passive resistance or token adoption. Institutional leadership often reinforces this conservatism through rigid accreditation systems that prioritize compliance over innovation.

However, several respondents proposed faculty exchange programs and partnerships with technology firms to catalyze cultural change. Embedding industry collaboration within academia could normalize CAAD as both a professional and pedagogical standard. Perceptions of CAAD's creative potential varied widely. Some faculty argued that automation dulls imagination, while students countered that algorithmic design expands the domain of creative exploration.

This debate mirrors the larger discourse on *human-machine co-creativity* (Mohamed et al., 2019; Soliman et al., 2019). Empirical evidence from digitally proficient studios indicated that CAAD promotes faster iteration cycles and reflective evaluation, enhancing both efficiency and conceptual depth. However, without pedagogical frameworks emphasizing critical engagement, these tools risk becoming mere representational devices. Thus, creativity in the digital era depends less on tool novelty and more on pedagogical intentionality**.**

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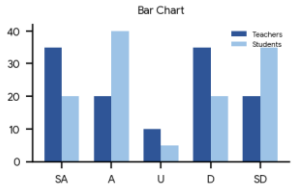
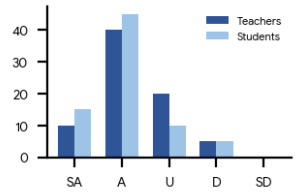
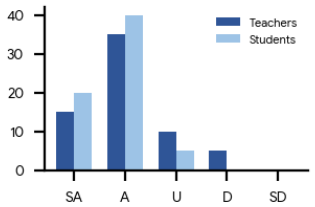
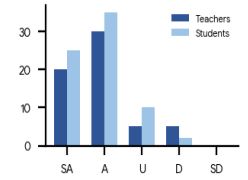
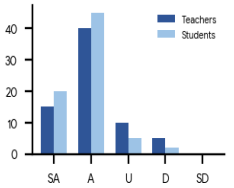
Table 5: Triangulation Chart on Studio Teaching Methodology (Author)

Themes	Traditional Mindsets	Digital vs. Hand Sketching	New Studio Setup	Research-Focused Studios	Regular Trainings
Survey Results: We collected 265 responses from architecture teachers and students in three cities.	No question was based on traditional mindsets. Hence no quantitative results were seen.	 Both teachers and students believe hand sketching is very important and should stay a key part of studio learning.	 Survey responses show that most teachers and students agree on using communication to show knowledge. This teaching style is widely accepted.  Most people in both groups also agree that we need to change how we teach to include digital tools (CAAD). Even with a few doubts, most agree digital tools should heavily shape architecture education.	 Most teachers and students agree on adding independent learning in the digital age. Very few disagreed, showing a positive view toward independent study skills.  Both groups strongly agree on using hands-on, experiential learning. There are few objections,	

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				meaning this practical approach is very popular.	
Interview Results: interviewed 60 teachers and students from three cities.	Teachers openly discussed the traditional mindset holding back changes. Most link this to how teachers feel about new technology. Students have mixed feelings. Since many haven't used digital tools much, they don't see the traditional mindset as a big problem.	Teachers are unsure about fully replacing hand sketching with digital sketching. Students are also unsure because they haven't been taught much digital sketching yet.	Most teachers want to focus more on the design process rather than just the final product. Most students also want a new setup that includes technology, focusing on process and teamwork.	No teachers talked about research-focused studios, likely due to the traditional view that architecture is mostly field work. No students mentioned research studios either, showing a lack of awareness.	Teachers didn't mention training programs, but did discuss the hard task of shifting to new methods. Students suggested that training for both teachers and students would solve the problem.
Studio Interviews Results 10 semi-structured Interviews were conducted with the students of the experimental studio.	These students have mixed views on the new methods. Because they recently used a digital studio, they don't see the traditional mindset as a major block.	These students prefer digital sketching more because they recently received digital training. They like it more than teachers and other students do.	These students strongly prefer digital tools due to their recent training, showing more interest than other groups.	These students like the research-focused studios they tried this semester and want future classes to include more research.	These students stressed that training is very important because they saw the difference between traditional and new tech-based methods.

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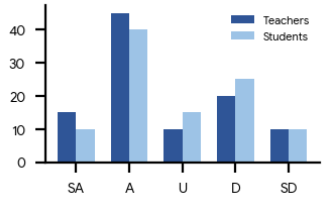
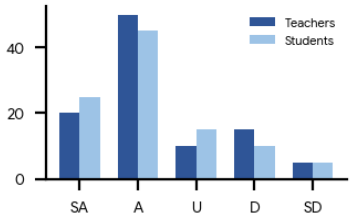
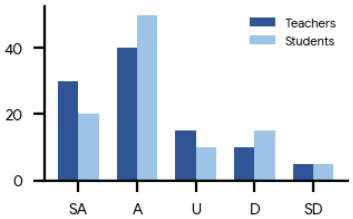
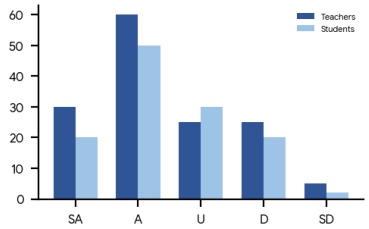
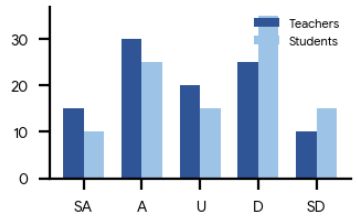
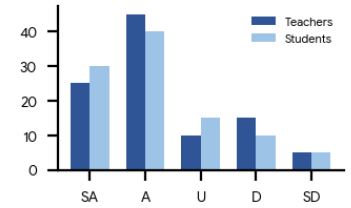
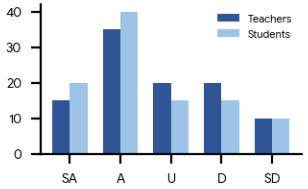
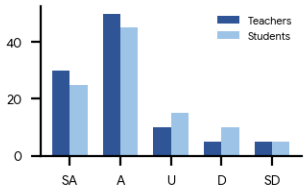
Table 6: Triangulation Chart on Technology Integration in the Studio (Author)

Themes	Challenges in Integrating Tools	Efficiency and Flexibility of Tools	Faculty Trainings	Hindrances in Architectural Learning
Survey Results: We collected 265 responses from architecture teachers and students in three cities.	 Most teachers and students agree that a lack of understanding makes digital tools (CAAD) feel new and challenging.  Both groups also strongly agree that traditional and digital methods are often viewed as separate types of learning, creating a noticeable contrast in design education.  Additionally, respondents broadly agree that poor integration stems from unclear educational goals, underscoring the need for more clearly	 A large majority of both teachers and students agree that digital tools boost creativity, showing strong acceptance of their creative potential. Very few disagreed, though some remain undecided, indicating minor doubts about whether these tools might slightly hinder the traditional design process.	 Opinions are split on whether graduates should stick to conventional design methods after graduation, with responses spread evenly across the board.  However, most respondents strongly agree that educational frameworks must change to include digital tools, showing a clear consensus that these tools should shape the future of architecture education.	 Most respondents strongly agree that digital education objectives should actively address cognitive challenges in the studio.  There is also broad consensus that the curriculum should be progressively updated, moving step-by-step from fundamental computer skills to advanced, cutting-edge design theory.

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	defined objectives.			
Interview Results: We interviewed 60 teachers and students from three cities.	Teachers noted that the biggest challenges are strict restrictions on using digital tools in the studio, internet plagiarism, and a divided mindset among faculty. Students also face significant hurdles, primarily tool restrictions, time wasted learning the software, divided teacher opinions, and a jury bias toward visually "fancy" digital final products over the process.	Teachers acknowledged that digital tools are flexible, efficient, and enhance creativity, noting their importance in the studio. Students were particularly vocal about this efficiency, highlighting that having the freedom to practice with these tools during the semester significantly boosts their creative output.	Both groups see a need for improvement in teaching staff. Teachers believe there is a strong need for more faculty training across all institutes. Students also strongly agree that better training for faculty would significantly improve their current learning situation.	Teachers view digital tools as a potential hindrance to architectural learning, primarily because they can be addictive and distracting. A notable number of students also agree that relying too heavily on digital tools in the studio can sometimes obstruct the core architectural learning process.
Experimental Studio Results: We interviewed 10 fourth-year students from the experimental fall 2023 studio.	Because they used digital tools extensively throughout the semester, these students didn't face many challenges integrating them. However, they noted that strict restrictions on which tools they could use remained the biggest hurdle.	These students strongly support updating the curriculum to fully accommodate new digital tools. They also noted that improving faculty training and increasing the number of trained teachers would greatly enhance the overall studio experience.	These students are highly inclined toward changing the curriculum. They strongly advocate for updating the current educational framework to properly integrate new digital tools.	Even with their advanced exposure to digital tools, these students believe that digital tools can sometimes hinder traditional architectural learning. However, they emphasize that formally updating the curriculum would help fix this issue.

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5. Discussion

This study uncovers a tension within Pakistan's architectural education system, where students, faculty, and institutions hold divergent views on the role of digital tools such as CAAD. Students tend to embrace these technologies as pathways for innovation and collaboration (Repon et al., 2021)While faculty often remain anchored in traditional approaches, they are concerned about the loss of design fundamentals. Institutions, caught between outdated policies and infrastructural limitations, struggle to facilitate meaningful integration. Studios, once seen as creative hubs, are now transitional spaces navigating the shift from handcraft to algorithmic design. In this context, CAAD is not just a tool, it disrupts conventional hierarchies by empowering students as active co-creators of knowledge. However, challenges such as limited access to resources, uneven digital literacy, and deep-rooted cultural resistance continue to widen the gap.

The digital divide is both technical and ideological(Holzer et al., 2007). Older faculty, trained in pre-digital environments, often see digital tools as threats rather than opportunities. This aligns with Bourdieu's theory of symbolic capital, where traditional expertise loses value in the face of emerging digital skills. Without institutional support for re-skilling, this resistance hinders progress. Comparative cases from countries like Turkey and Malaysia suggest that faculty training, backed by clear policy, can accelerate digital adoption. In Pakistan, a similar transformation is needed, but it must also address colonial-era legacies embedded in assessment systems and accreditation structures.

A significant theoretical contribution of this study is the shift from representational to generative learning. CAAD enables students to explore design through computation rather than mere depiction. However, this shift requires foundational skills in geometry, coding, and data, areas often overlooked in current curricula. Without this grounding, digital engagement risks becoming superficial. Traditional evaluation practices also conflict with digital processes. Studios still tend to assess polished final drawings rather than iterative development. In contrast, CAAD inherently values the process, each command and variation representing a moment of reasoning. To harness this potential, assessment must move toward process portfolios that celebrate experimentation and failure as part of learning. Importantly, digital workflows democratize critique. By focusing on algorithms and logic rather than polished visuals, peer feedback becomes more analytical and less subjective. This fosters a collaborative learning culture, moving away from hierarchy and toward shared authorship. Rather than viewing the digital shift as a threat to tactile design traditions, the study argues for a balanced integration. Manual drawing and computational modeling each offer unique cognitive benefits, and together they can enrich architectural education. Acknowledging this synergy can ease cultural resistance and open space for innovation. The digital turn also reshapes social dynamics in the studio. Relationships between teachers and students become more collaborative, supporting peer learning and collective problem-solving. Yet, current academic systems still reward individual output, limiting institutional recognition of these new modes of engagement.

Finally, faculty development emerges as the linchpin for long-term change. Without professional training and support, digital reforms risk becoming superficial. Institutions like PCATP and HEC play a key role in mandating digital literacy programs, building industry partnerships, and aligning academic content with evolving professional standards. To truly modernize design education in Pakistan, digital literacy must be treated as a core pedagogical skill, not a bonus. This shift would validate younger faculty

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and bridge generational divides, fostering a more inclusive and future-ready architectural pedagogy.

6. Conclusion

This study examined how CAAD is transforming the way architecture is taught in design studios across Pakistan, using a triangulated qualitative approach. The research shows that students often see CAAD as a powerful tool for critical thinking, creative exploration, and interdisciplinary collaboration. Meanwhile, faculty perspectives vary; some are adapting to a blended teaching style that includes digital tools, while others remain attached to traditional, manual methods. Institutions, on the other hand, face practical challenges like limited resources, inflexible policies, and uneven implementation. These dynamics have created a mixed learning environment marked by excitement, hesitation, and systemic constraints. Still, within this complexity lies a key opportunity: the rise of a hybrid teaching model that balances technological proficiency with cultural and contextual relevance.

Drawing from the empirical findings and theoretical synthesis, the paper proposes a Hybrid Digital Pedagogical Framework (HDPF) comprising five interdependent layers:

i. Cognitive Layer: Introduce CAAD as a medium for reflective reasoning rather than presentation. Encourage iterative modeling, simulation, and visual programming to cultivate critical design cognition as shown in the framework in Fig. 1.
ii. Curricular Layer: Scaffolded Integration and Embed digital literacy progressively across all academic years. Early stages emphasize conceptual visualization; advanced stages focus on parametric design, data analytics, and fabrication. This leads to the exploration of interdisciplinary approaches in studio teaching.
iii. Inquiry Epistemic Layer: Co-learning and Process Evaluation. eplace hierarchical critique with peer-learning mechanisms. Evaluate students on process documentation, experimentation, and collaboration rather than end products.
iv. Critical Thinking Layer: Where students are taught to think critically at every design stage, this can be achieved through continuous professional training, digital labs, and partnerships with technology firms.
v. Student-Centered Layer: where Contextual Adaptation**,** balance computational efficiency with cultural authenticity. Integrate local materials, crafts, and social narratives into digital experimentation, ensuring that the “algorithmic studio” remains grounded in human context.
vi. Implications for Global South Pedagogies. The Pakistani case provides a microcosm of challenges faced across the Global South: infrastructural disparity, curricular rigidity, and colonial pedagogical residues. The proposed hybrid model emphasizes agency, adaptability, and contextual intelligence as antidotes to these systemic barriers. Rather than imitating Western digital paradigms, local institutions can cultivate *situated innovation*, technological advancement grounded in regional realities. By reframing digital adoption as a cultural negotiation rather than a technical upgrade, architecture schools can move toward pedagogical sovereignty, generating knowledge that resonates both locally and globally.
vii. Limitations: While the qualitative depth of sixty interviews offers rich insight, the study does not claim statistical generalization. Limitations include uneven

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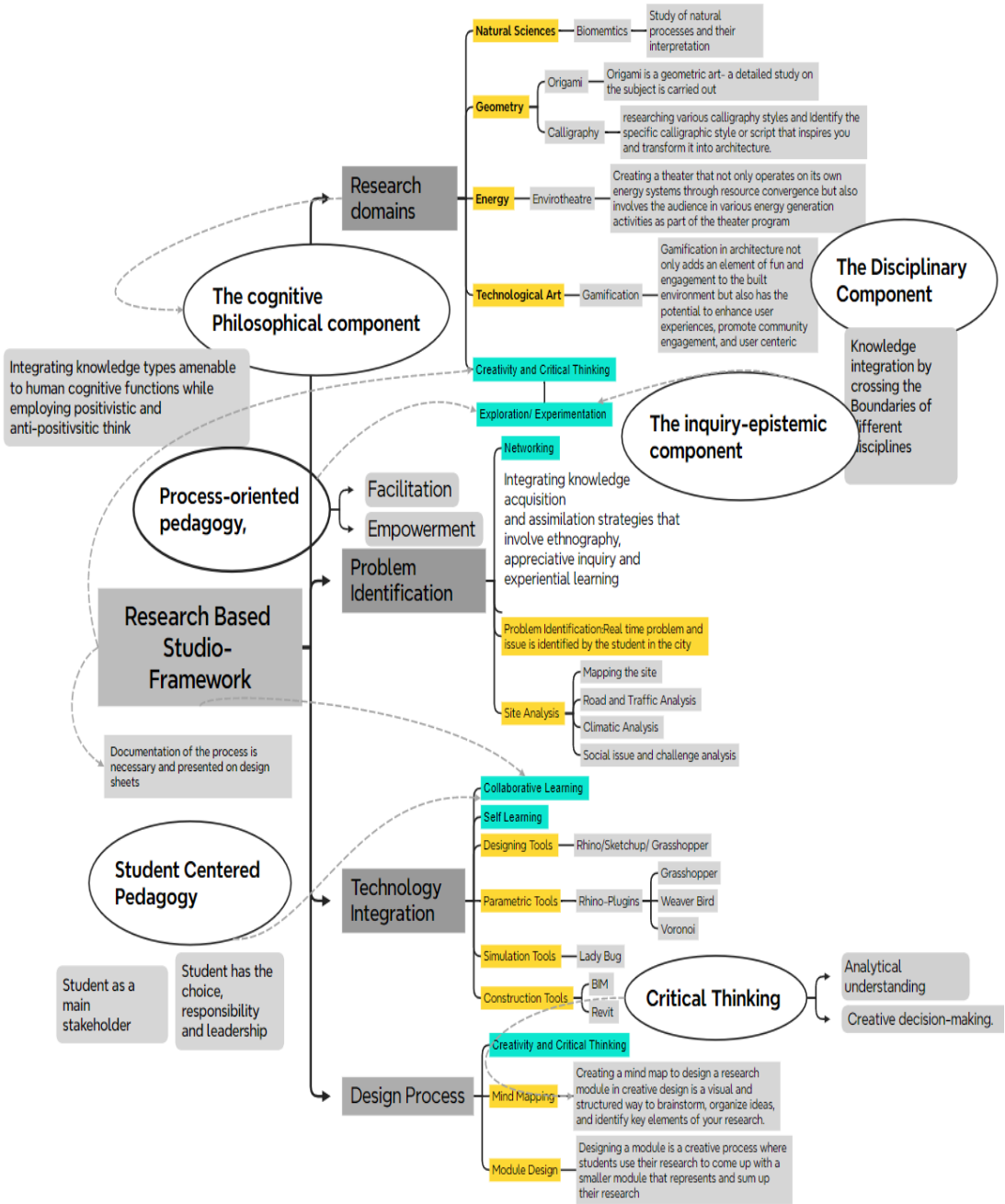
institutional representation and possible self-selection bias favoring digitally inclined respondents. However, the triangulated design mitigates these constraints by cross-referencing diverse perspectives and emphasizing interpretive validity over quantitative breadth.

viii. Future Research: Further studies could expand this inquiry through longitudinal tracking of institutions implementing CAAD reforms, comparative analysis across South Asian contexts, or quantitative assessment of learning outcomes before and after the introduction of a hybrid curriculum. Exploration of AI-driven generative design and immersive technologies (VR/AR) may also reveal new cognitive and ethical dimensions of digital pedagogy.

Figure 1: Hybrid Framework for Pedagogical Interventions in studio (HDPF)



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Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical standards of the institutional research committee. All participants provided informed consent prior to participation, in accordance to the ethical standards. The Institutions were informed about the research being conducted and written consent was signed by the HOD's of all departments.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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