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RETHINKING ARCHITECTURAL EDUCATION THROUGH COMPUTER-AIDED DESIGN AND TRANSFORMATIVE STUDIO PEDAGOGY

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Abstract
Architectural education in Pakistan, established in 1954, faces the challenge of adapting to a rapidly evolving design and technology landscape. This study examines the integration of Computer-Aided Architectural Design (CAAD) within Pakistani architecture studios, highlighting the influence of historical educational practices. Critical obstacles identified include outdated infrastructure, theoretically focused curricula, and insufficient collaborative mechanisms necessary for effective technology adoption. Conducted in Fall 2023, the research implemented a CAAD integration framework in a fourth-year architecture studio at the University of Engineering and Technology, Lahore. Findings reveal gaps in pedagogical approaches, including limited student engagement, restricted access to modern tools such as CAAD and BIM, and inadequate training in emerging digital technologies. The study offers actionable recommendations for educators, policymakers, and industry stakeholders to enhance studio pedagogy, promote transformative learning, and advance digital competencies in architectural education.

INTRODUCTION

The evolution of architectural practice, driven by technology integration, presents an opportunity to enhance our educational framework. By updating curricula to reflect these advancements, we can better equip future architects to thrive in a rapidly changing world. This paper argues for the involvement of architecture students in research by introducing a framework that integrates experiential learning with assessment and instruction methods. It emphasizes the importance of providing students with essential source materials and teaches them how to generate information effectively. Afterward, students will want to improve their abilities ceaselessly. The more experience the students have, the more prominent and profitable their innovative reasoning, the more various their activities, the more unreservedly and adequately the free venture work, and the more significant the learning intentions and premiums.

This research discusses new techniques, instruments, and procedures for constructivist learning and how using CAAD in the studio can help improve the overall situation. This approach combines virtual and face-to-face activities, creating a blended learning experience. This method can enhance students' learning by fostering a deeper understanding of the material, encouraging them to learn from their peers' work, and improving the quality of their designs. Technology plays an essential role in enhancing the learning system. Teachers, therefore, should use modern teaching tools and techniques. Modern teaching tools are used to make learning sessions interactive

and motivating. Nowadays, Classes are equipped with Modern teaching tools such as Interactive Whiteboards, Visualizers, response systems, projectors, virtual software, etc. Many subject topics can be taught better with Modern teaching tools.

Evolution of Architecture Education in Pakistan

The evolution of architectural education in Pakistan has been a gradual and uneven process. It all began with establishing the first school of architecture during the British colonial period in 1904. Over the decades, the number of institutions providing architectural education has increased significantly, from a mere two in 1958 to a robust sixteen by the end of 2007, and to sixteen architecture schools only in Lahore. This remarkable growth reflects the rising demand for architects in the country, driven by the booming building industry. The early pioneers in architectural education, such as the Government School of Architecture in Karachi and the Department of Architecture at the University of Engineering and Technology in Lahore, have played a crucial role in setting the pace for formal architectural education in Pakistan. The subsequent establishment of institutions like the Indus Valley School (IVS) of Art and Architecture and the architecture department at Beaconhouse University in Lahore (BNU) at the University of Karachi has further expanded the opportunities for aspiring architects across the country, catering to the newer vision in architecture (Naz, 2000).

However, this rapid expansion has also created a sense of competition among the institutions, leading to an exchange of opinions on the issues affecting the profession. The recognition of architects as an expert body, through establishing the Pakistan Council of Architects and Town Planners in 1983, has been a significant milestone in the field's evolution (Ahmad, 1988.). Despite this progress, the geographical distribution of architects remains uneven, with most being confined to the major urban centers of Karachi, Lahore, and Islamabad. Addressing this imbalance and ensuring equitable access to quality architectural education across the country will be crucial for the continued development and growth of the profession.

Architectural education has traditionally focused on imparting technical skills and facilitating studio-based instruction.(Kumsal et al.,2017)However, now in Pakistan, this narrow approach has faced criticism for its lack of a culture that encourages critical inquiry and open debate. This leads students to accept pre-determined solutions uncritically without rigorous analysis.(Naz, 2000). The inherent interdisciplinary nature of architecture, encompassing technology, human-centered design, and aesthetic considerations, has often been overlooked, with instructors continuing to teach in the same manner they were taught. Over time, the holistic understanding of architectural education has gained recognition, and the increasing complexity of projects has necessitated the integration of computers and information technology within design studios (Mumtaz et al,.2009). Despite these, Architectural education in Pakistan has traditionally focused on imparting technical skills and facilitating studio-based instruction.

The current state of architectural education in Pakistan necessitates a fundamental shift towards a more holistic and critically oriented approach ((Iqbal et al, ,2020)The traditional focus on technical skills and studio-based instruction has been criticized for lacking critical inquiry and open debate. This leads students to accept pre-determined solutions uncritically without rigorous analysis.

Architecture training across schools in Pakistan

Lahore's architecture reflects a strong regional focus, predominantly drawing on traditional styles and materials, contrasting with Karachi's contemporary and modern trends. Meanwhile, Lahore and Islamabad each exhibit distinct architectural identities shaped by their local contexts. These architectural trends shown in Table 1 greatly influence the academic settings of the architecture schools in these cities.

Table 1- Influence of the Region on the Architecture Training in the different cities of Pakistan. (Author)

	ISLAMABAD	LAHORE	KARACHI
Contemporary Architectural Style	Modernism	Contemporary, Islamic, Gothic	High-Rise, Parametric, Contemporary
Dominant Architectural Style	Modernism, Neo-Classical	Traditional, Contemporary	Contemporary High-Rise
Architecture And Urbanism	Proper Planned	Less Dense than Karachi	Dense
Materials	Brick	Brick	Concrete
Historic Context	Negligible	Maximum	Medium
Regionalism Approach	Lowest	Highest	Medium
Famous Architects	Ejaz Ahad	Nayyar Ali Dada	Arshad Shahid Abdullah
Density of Buildings	Low	Medium	High

Evolution of the Architecture Training: Importance of Research in Architectural Pedagogy

Lecture-based courses offered in most educational architecture institutes involve a research component, which may be library research activities or mere site visits. (Asghar, 2024). There are two main ways to improve design education. First, using studio-based learning where hands-on experiences help boost creativity, teamwork, and problem-solving skills that are super important in architecture (Lynas et al., 2013). Second, incorporating research into architecture courses shows how it can improve learning by connecting academic questions with design innovation and real-world applications. (Rider et al., 2024)At the same time, it is essential to investigate the status of research methods as a course offered to architecture students. Pakistan has no core research methodology curriculum compared to other countries, especially at the undergraduate level. The program's objectives could benefit from incorporating elements related to research, knowledge acquisition, application, and experiential learning. This would enhance the educational experience and prepare participants for real-world challenges. A new framework is needed to better meet the new era's needs.

Research Method:

The researcher conducted a research-based studio involving technology and the latest digital tools during the fall of 2023, from September 2023 to December 2023, at the Department of Architecture, University of Engineering and Technology Lahore. It was a sixteen-week studio with intense training on using various digital software, including Rhino and Grasshopper. The instructor applied the components of the above strategic plan (Fig.1) during the studio with a focus on research and technology. The studio emphasized research-based methodology, and then the students were asked to complete a Google questionnaire about the studio and the technology they used this semester. Their responses were recorded and are presented in the next section. The questionnaire was designed based on two inquiries: Understanding the research challenges during the design process and using CAAD tools and technology in Studio. The results of the questionnaire are discussed in the following sections:

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Research Findings:

Understanding the Research Challenges during the Design Process:

Questions	Responses
2a. Discuss any challenge, change, or difficulty you faced while conducting research and its transformation into an architectural element.	a) For me personally, the process from a distance seemed very otherworldly and interesting, but when I delved deeper into the domain ‹I would not be lying if I said that I found it quite intimidating, I could not justify or rather mold my research part into design, the software's did not give me much trouble though. b) It was our first experience delving into research and implementing a project based on it. The introduction to research methodology and technicalities should have been integrated into our degree program. Right now, I am finding it tough because we must learn how to do research and work on projects simultaneously. It is too much for us to handle now. c) Transforming research into the module is quite difficult d) How everything can be derived from research e) It was obviously due to a lack of research data. Creating a story and then connecting it with something architecturally is not difficult for me, but dealing with a concept I have never heard of was initially challenging to comprehend. I then had to narrow down my story according to it because there is no proper workflow for gamification f) My studio for this semester was more virtual, and I learned how to work in the online mode. The research part was very interesting and fun. I especially enjoyed learning how to turn nature-inspired stuff into modules in Grasshopper! g) It was a complicated process because it was my first digital research studio where I had to learn and use different new software.

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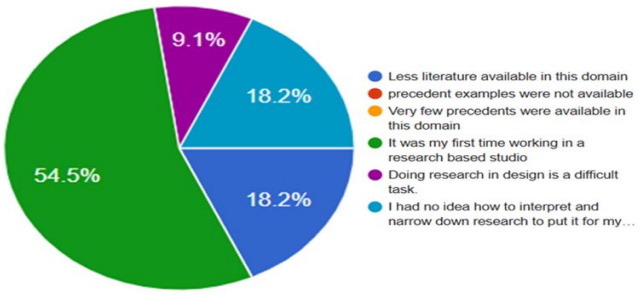
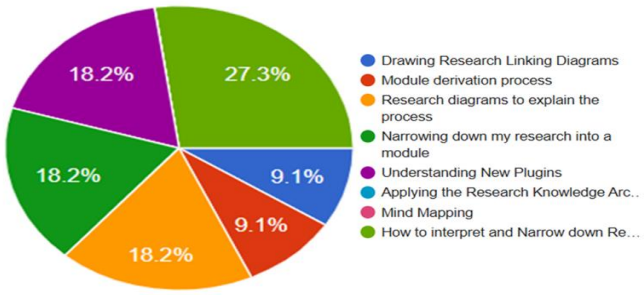
2b. What was the biggest challenge in conducting the research that was the studio requirement?



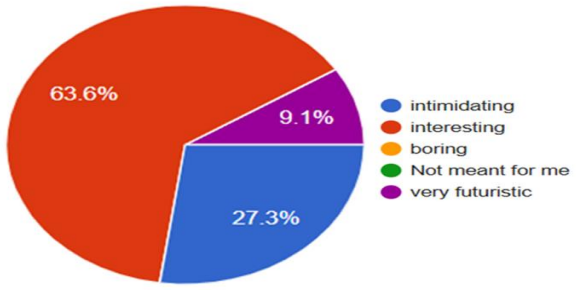
The biggest challenge in conducting the research for the studio requirement was that 54.5% of respondents were new to working in a research-based studio, while other notable challenges included interpreting and narrowing down research (18.2%), lack of available literature (18.2%), and difficulty in research and design tasks (9.1%).

2c. Which component of the Research process, did you find as the most challenging?



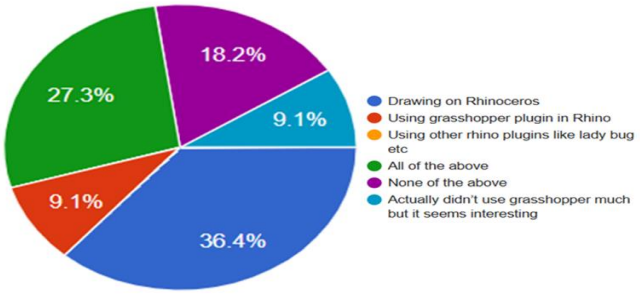
The most challenging component of the research process for respondents was applying research knowledge (27.3%), followed by equal challenges in understanding new subjects (18.2%), narrowing down research into modules (18.2%), and explaining the process through research diagrams (18.2%), with fewer respondents finding difficulties in the module derivation process (9.1%) and drawing research diagrams (9.1%).

2d.I found deriving concepts through research and then applying them to design very



Regarding the challenge of deriving concepts through research and applying them to design, 63.6% of respondents found it interesting (red), 27.3% found it intimidating (blue), and 9.1% found it very futuristic (purple).

2e. Which software was easy to use?



The easiest software to use was drawing on Rhinoceros (36.4%), followed by all of the above tools (27.3%), with fewer respondents indicating Grasshopper plugins (9.1%), not using Grasshopper much but finding it interesting (9.1%), and none of the tools (18.2%).

REFLECTION:

The findings show that most participants found the studio experience a worthwhile learning opportunity. This project gave them valuable knowledge about the essential components of successful research-driven

design. Although initially intimidating, converting information into architectural features was interesting and enlightening. One of the students said, "Conducting research and transforming it into architectural elements posed several significant challenges for me. The process initially seemed intriguing and otherworldly, but as I delved deeper, I found it quite intimidating and complex. Bridging the gap between my research findings and the design process proved difficult, as I struggled to effectively justify or mold my insights into a cohesive and meaningful architectural design".

The most important parts consisted of connecting research and design. This step fostered development towards combining research and technical work. Furthermore, this step facilitated the implementation of such strategies into the educational curriculum at the outset. As narrated by another student: While the software tools did not present major technical issues, the overall experience of this research-driven design process was uncharted territory for me. Integrating research methodology and technicalities more deeply into our degree program would have better prepared me and my peers. We must simultaneously learn advanced research skills and immediately apply them to complex design projects, which can feel overwhelming and leave us ill-equipped. This method's potential is illustrated by creating narratives connecting with innovative architectural concepts. It encourages exploration into transforming nature-inspired materials into versatile digital modules for modern design and construction. By merging storytelling with advanced design practices, this approach enhances our understanding of sustainable architecture and supports the development of structures that harmoniously integrate with their natural environments.

Navigating the shift from research to schematic design was the most challenging part; it called for a sophisticated comprehension of the connections between conception, research, and actual design. The importance of a studio teaching approach that strikes a balance between learning research techniques and using them immediately in project-based learning has been highlighted by this experience. One of the answers stated that transforming academic research into a functional architectural module is an immensely challenging task. A particular hurdle was understanding how to integrate research to inform and drive the design process. The lack of research data on my chosen topic also presented significant difficulties. Crafting a cohesive narrative and effectively connecting it to an architectural concept with which I was initially unfamiliar proved quite challenging. I had to significantly narrow my focus to adapt my research-driven story to the constraints of the project.

Another student quoted: Despite these substantial hurdles, my studio's research process this semester was engaging and insightful. Discovering innovative ways to translate nature-inspired elements into intricate Grasshopper modules was a particularly fascinating aspect. Overall, navigating the critical transition from research to schematic design remained the most challenging part, as I struggled to thoughtfully translate my academic findings into coherent design principles and a compelling architectural language.

Some respondents argue in favor of abandoning traditional hand drawing techniques and replacing them with digital sketching solely for its effectiveness and accuracy. However, a significant proportion contests that hand sketching is integral in the conceptualization phase and needs to be preserved. Others appreciate that the answer is contextual and depends on the task, appreciating both digitally and physically drawn sketches. Arguably, the most reasoned response endorses a hybrid solution combining both approaches to different extents. It represents a more sophisticated and responsible attitude towards the influence of technology on design education and practice.

The issue concerning the facilitation and supervision processes related to the new technology in the design studio teaching

context suggests a divergence of views. This data suggests that a myriad of methods are being developed and reevaluated in what appears to be a very intricate and complex framework. On the one hand, a significant majority (54.5%) emphasized the importance of programming and visual adjustments in adapting to new technologies. This inclination points to the increasing relevance of digital skills, recognizing the evolution of the design environment. Consequently, students must develop proficiency in new digital tools and workflows to remain competitive. To facilitate students, educators must consistently revise curricula and teaching methods to meet the requirements of rapid technological advancements.

However, a significant portion (27.3%) prefers to stick with traditional teaching methods. This group values established educational techniques that have proven effective over time. These traditionalists recognize the timeless importance of basic design concepts and manual abilities. With a growing preference for digital tools, manual tasks risk being eclipsed by an excessive focus on digital methods. Students can develop an integrated set of design skills by striking a balance between digital and analog methods.

A comparatively smaller group (9.1%) supports self-learning and research-based methods. They acknowledge the need for independent research and critical thinking in navigating the rapidly changing technological landscape. This approach fits in with the trend of teaching methods focusing more on students, helping them get involved in their growth. As the design industry keeps changing, learning how to learn for life might be just as important, if not more so, than picking up specialized technical skills. These results imply that while maintaining the fundamental creative processes and pedagogical techniques that have proven successful, design educators must carefully evaluate how to use technology in their curricula strategically. To best meet the varied demands of design students, a nuanced, context-sensitive, and reflective approach is required; a one-size-fits-all strategy is unlikely to be effective.

Divergent opinions exist, with some favoring digital learning techniques over conventional teaching approaches. Among the respondents, only 36.4% support a total transition to digital learning. Their support for digital learning arises from the increased chances for personalization, interaction, and access to a wider variety of learning materials. This group has a forward-thinking acceptance of technology and its capacity to revolutionize the educational process. The remaining responders, however, seem to have more complex opinions on this topic. This group is aware of the need for change in design education. However, they consider multiple factors rather than presenting a dichotomy between digital and traditional. The unlabeled segment suggests that additional considerations, such as the pace and nature of change, may influence perspectives on this topic. The 36.4% of respondents who accept the need for change reflect the field's changing needs and technical improvements. The findings highlight the necessity of a sophisticated and balanced strategy that acknowledges the advantages and disadvantages of both traditional and digital techniques. It is critical to carefully evaluate how to strategically integrate emerging technology while maintaining the fundamental creative processes and educational methods that have proven successful throughout time as the discipline of design develops.

Although the student might find adjusting to digital design tools complex, this outcome indicates a chance to improve the curriculum and instructional strategies. We can read the student's discontent as a desire for a more successful integration of CAAD technology into the design process rather than as an issue. The institution can enable students to become more proficient in utilizing emerging technologies by attending to their concerns and creating instructional strategies that better facilitate the shift to digital design methodologies. Ultimately, this move toward a smoother integration of CAAD technologies might improve students' capacity for problem-solving, encourage their creativity, and equip them to deal with the

rapidly changing world of architecture in the twenty-first century.

Use of CAAD Tools and Technology in Studio

Almost all thirteen students were introduced to Rhino and Grasshopper for the first time this semester through a guest lecture and with the help of Teacher Assistants (TAs). A session on another Rhino Plugin, Lady Bug, that performs a Climatic Analysis of the site and the building by using simulations was held for the students. They were given a week to work and understand the workings of this Plugin. This questionnaire was based on questions about experience in a studio working with visual programming in Grasshopper and other projects.

Questions	Responses
3a. What was the most difficult learning experience in this studio and why?	a) I found the steps to represent the design process a bit difficult. The rest of the experience, including the innovative projects we saw, the workshops, and the design thinking process we experienced, all felt great. b) Grasshopper, as that includes a lot to understand c) Learning and using new software d) Learning the design tools was not difficult, but implementing and translating them into the design process was somewhat difficult. e) New software and so much data to consume f) My research part and literature review was difficult because we do not have as many projects as I am doing. Other than that, there was not as much difficulty g) Grasshopper, limited time for learning and doing h) Being online
3b. What was the best part of the design process in this studio and why?	a) Seeing Ideas Come to Life and witnessing abstract concepts evolve into tangible, detailed digital models was exhilarating. It was the phase where creativity met technical expertise, laying the foundation for the physical realization of a vision. b) Research because this allows us to widen our minds c) Learning how to connect research to design d) Learn how new tools can help you conceptualize and implement your design ideas on paper digitally or physically. e) We were allowed to explore our interests but very overburdened f) Creative support from the Instructor was the best part I always do my parts but always I have to be let's creative because my ideas were not welcomed there but this time Explaining and talking about new ideas and technology gave me a huge exposure g) Research-related project, more confident about the idea or concept of the project h) Exploring parametric design and new software
3c. If agree or strongly agree then WHY?	a) As it involves a lot to understand b) It is quite different from all the previous software we have used c) Because we had first to learn some basics of the software and then implement the same software in translating our design in the same semester, this process was time-consuming and hectic. That would not have been an issue if we had already learned the software. d) Limited time for learning and doing at the same time e) Because it is an entirely new and complex software plugin, time scheduling for me was limited
3d. What is the best learning	a) Expert guidance and access to experienced mentors and professors provided valuable insights and guidance. Learning from their experiences and expertise was instrumental in shaping one's approach to design and problem-solving.

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experience of the studio and why?	b) Research c) Research d) Discussion with The instructor and doing a literature review to connect Architectural Criticism with Technology was The best part e) Self-learning is best, but time was limited f) Learning about different techniques and research methods that can be incorporated into design projects.

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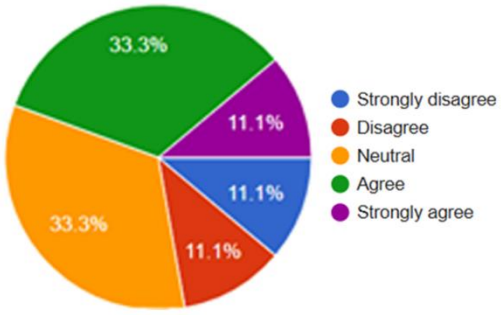
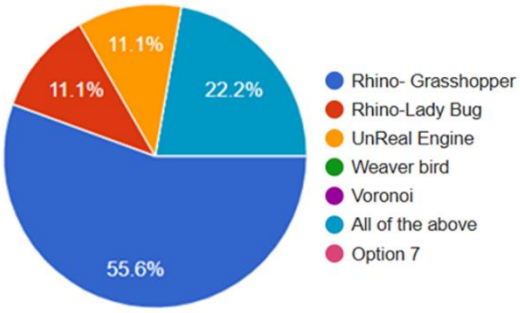
3e.What was the biggest challenge in conducting the research that was the studio requirement?



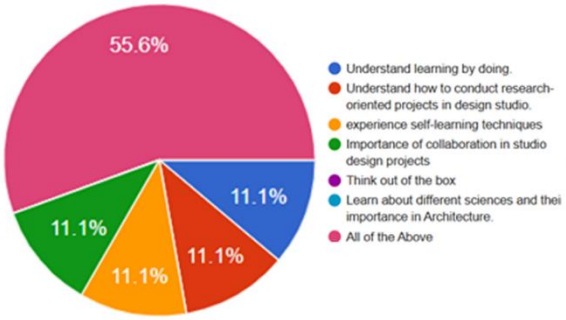
The biggest challenge in conducting the research for the 2D requirement varied, with 33.3% agreeing, 11.1% strongly agreeing, 11.1% strongly disagreeing, 11.1% disagreeing, and 33.3% being neutral.

3f.The best software/plug-in that I have learned in this studio is:



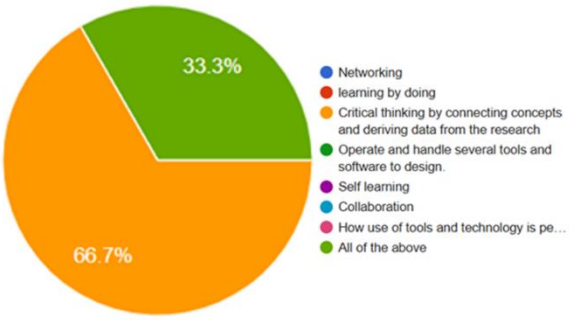
The best software plugins learned in the studio were Rhino and Grasshopper, favored by 55.6% of respondents, while 22.2% selected all of the above, with smaller proportions opting for Unreal Engine (11.1%) and Rhino with Ladybug Engine (11.1%).

3g. The use of various digital tools in this studio helped me to:



The use of various digital tools in the studio proved beneficial, with 55.6% indicating all of the above, while smaller proportions highlighted the importance of collaboration in studio design projects (11.1%), experiencing self-learning techniques (11.1%), understanding how to conduct research-oriented projects (11.1%), and understanding learning by doing (11.1%).

3h. What have you learned this semester in the design studio?



In this semester's Design Studio, 66.7% of respondents emphasized critical thinking by connecting concepts and deriving data from research, while the remaining 33.3% selected all of the above options, including networking, learning by doing and operating and handling several tools and software to design.

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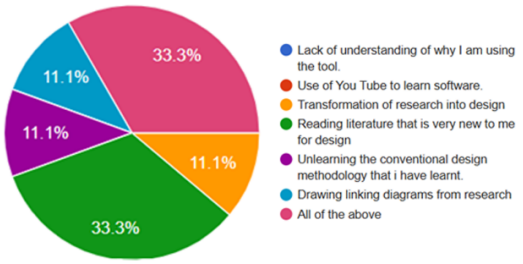
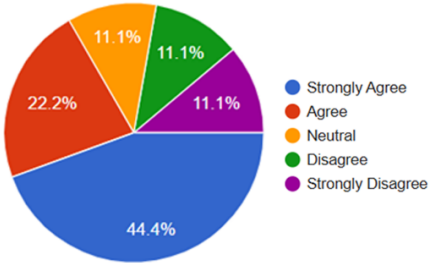
3i.What were the basic challenges I had to face while going through this semester?



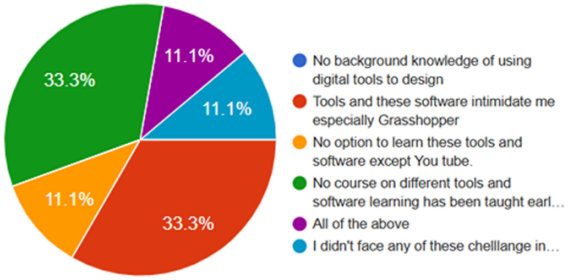
33% selected all of the above options, encompassing the transformation of research into design, reading new literature, underlining conventional design methodology, and drawing linking diagrams from research.

3j.The most challenging part of this studio was learning and working on Grasshopper



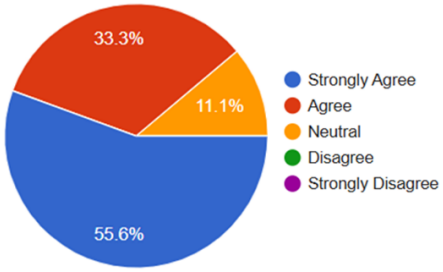
4.4% strongly agreed, indicating a significant challenge, while smaller proportions either disagreed, were neutral, or agreed to varying extents.

3k.The main challenge of working with software and tools in this studio is:



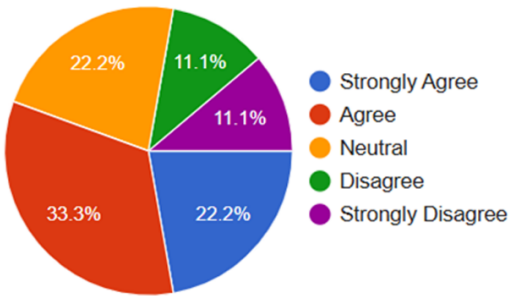
33.3% indicated intimidation by tools and software, particularly Grasshopper, while others mentioned facing no challenges, relying solely on YouTube for learning, or the absence of earlier courses on different tools and software.

3l. Learning Visual programming and Parametric modeling should constitute a major part of the curriculum in Architecture.



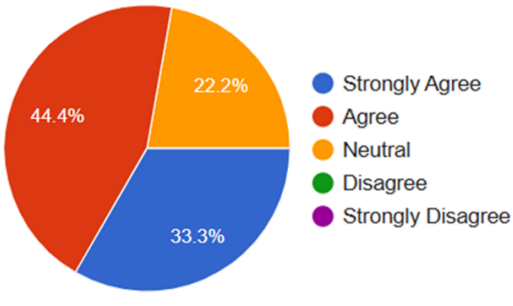
55.6% strongly agreed, indicating a strong desire for inclusion, with smaller proportions showing agreement or neutrality.

3m. Almost all of us are found to be grappling with tools and technology in the studio rather than controlling it.



Responses varied, with 22.2% strongly agreeing, 33.3% agreeing, 22.2% being neutral, and smaller proportions disagreeing or strongly disagreeing

3n. Learning and critical thinking are enhanced in this studio where tools and software are used to design.



The majority (63.3%) strongly agreed with this statement, with additional agreement from 44% of respondents and neutrality from 22%.

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REFLECTION AND DISCUSSION:

Students said that adjusting to the representation of the creative process was the most challenging part of their experience in this workshop. They found the procedures necessary to explain the process intimidating, even though the creative projects, workshops, and design thinking exercises were energizing. They had a steep learning curve when they initially discovered Grasshopper, a software program with many intricate capabilities. Furthermore, because it was occasionally challenging to integrate and translate these design tools into the actual design process, learning and using new software was a constant problem. Another challenge was the sheer amount of fresh data and knowledge they had to take in. Navigating their research and literature review section was especially difficult because they had not previously been exposed to such assignments. Apart from these particular challenges, though, the studio experience was enjoyable generally, and with persistence and the help of their teachers and classmates, they overcame most challenges.

According to the findings, the students found it most thrilling to see their ideas come to life and to see abstract thoughts transform into concrete, intricate digital models during the design studio process. The foundation for the physical implementation of their study was established during this stage, where technical know-how and creativity collided. They were able to increase their knowledge through the research process. Effectively relating research to design was a crucial skill to acquire. It was beneficial to investigate new technologies that made it easier for them to conceptualize and execute their design concepts, both digitally and physically. This is aligned with the earlier researches (Soliman, 2017) This discusses the efficiency and enhanced thinking skills with the use of CAAD. The workload occasionally felt oppressive, even though they could pursue their interests. The best aspect was the instructor's innovative support, which allowed them to freely exchange and discuss cutting-edge concepts and technology, giving them important visibility. There was increased confidence in the underlying premise because the initiative was research-focused. Investigating parametric design and new software was a fun and fulfilling aspect of the procedure.

The findings show that students used a variety of strategies to overcome the obstacles in the studio. Some people faced the challenges head-on, accepting them as chances for personal development. Others stuck to their guns, opposing change and holding fast to their beliefs. Some students found themselves in a middle ground where the circumstances of each case determined their actions. Others choose to partially change their approaches to find a balance, carefully balancing the old and the new. Ultimately, the studio experience has shown students that learning technical tools is not the only thing that matters. It involves stretching the limits of their talents, negotiating the unknowns of design, and developing into innovative problem solvers. The difficulties they encountered were opportunities to develop as a society and individuals, not just barriers to overcome. When asked about the best software and skills they learned in this studio, the students said that Grasshopper and Rhino had become old friends because they had frequently used them. They also said the tools were so dependable and versatile that 55.6% found them comfortable. They allowed them to construct their intricate concepts familiarly and comfortably masterfully. However, 22.2% of them ventured into the unexplored realm of Unreal Engine, demonstrating their love of the unfamiliar (Asghar et al., 2024). One could feel the excitement of discovering new possibilities. In addition, 11.1% of them were the dynamic team of Ladybug Engine and Rhino. The abilities they acquired were as varied and significant as those outside of the software. One of the most important adventures for 55.6% of them was networking. Fueled by their voracious curiosity, 11.1% were drawn to the secrets of research-oriented enterprises. Moreover, for an additional 11.1%, the experiential,

immersive, and often messy aspects of "doing" turned into a dance they treasured.

Ultimately, they discovered that tools are merely means to a goal. What molds them as designers and problem-solvers is how they use them, push the envelope, and embrace the learning process. Mastering methods and learning about the surprising turns and joyful surprises that accompany the creative process were the main goals of this studio. Additionally, the results show that using the visual programming tools in the studio was difficult for the first time. Although they freely admitted that they experienced the same challenges with the technology, they also believed it should not define or limit them. They see it as a chance to harness invention's power rather than a way to follow what everybody is doing without much gain. They have learned to welcome obstacles as opportunities to push the limits of what is possible rather than feeling overpowered by them. They have discovered that they may turn challenges into opportunities for learning and development by approaching this digital task of mastering the new program with an open and flexible mindset. Instead of the other way around, students believe they can shape technology to fit their artistic vision. One of the students responded: Though the journey has been filled with ups and downs, I am grateful for the chance to learn and grow. The struggles have not only tested my resilience but have also ignited my passion for innovation. As I move forward, I am determined to continue pushing the limits of what I can achieve, using technology as a tool to bring my creative vision to life.

Many students were scared by the intimidating and complex nature of visual programming applications such as Grasshopper. Nonetheless, some of their contemporaries welcomed these difficulties and became pioneers who were unafraid of the digital wilderness. Some looked to YouTube lessons and other digital Sherpas for help navigating the highs and lows of software exploration. On the other hand, some people complained that there should have been more training on particular tools and software, since they were uneasy about the lack of a roadmap. Regarding the connection between technology and the studio experience, most students found it challenging to use the tools and technology, instead of being able to control them fully. Many saw themselves as collaborators rather than puppeteers, acknowledging the collaborative relationship between creator and creation. While some stayed neutral, possibly watching the conflict from the sidelines, a few claimed control of the digital world and positioned themselves as tech whisperers. In the end, students' technological experiences were varied and highly intimate. Their difficulties were barriers to surmount and chances for personal and collective development.

Strategies for Transformative Studio Pedagogy in Pakistan:

One less-researched area is integrating technology and digital tools to address various issues. Oxman (2008) discovered that digital technologies challenge traditional architectural pedagogy, suggesting that new design thinking models, knowledge creation, and media literacy are essential for contemporary education. Conversely, the research by Asghar (2024) explains how integrating digital tools and technologies transforms the design process in Pakistan. This research emphasizes the necessity of incorporating digital tools into academic frameworks to align architectural education with current professional practices. The proposed strategies are holistic, encompassing several domains, each involving different issues and mechanisms outlined below.

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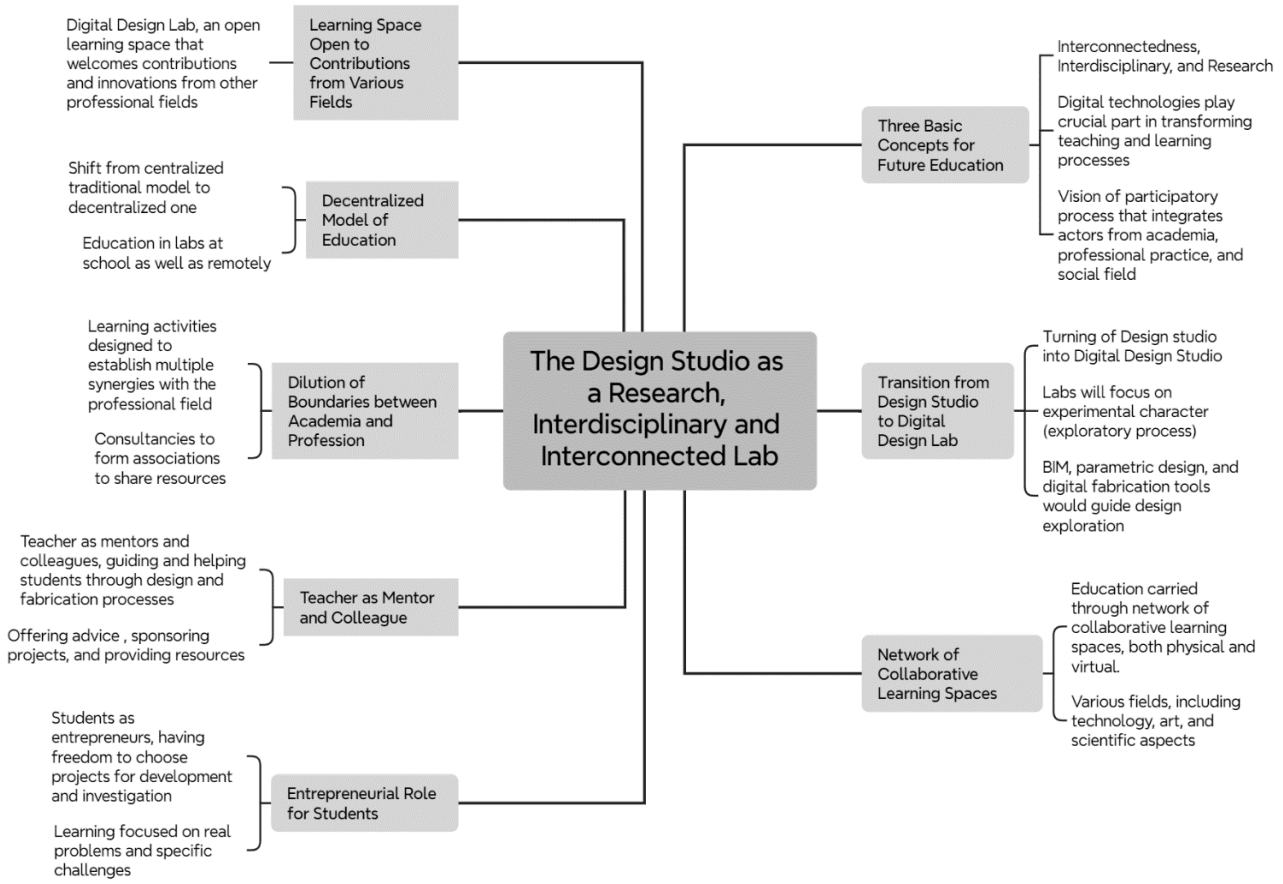

Figure 1- The Strategic Plan for Architectural Design Studios in Pakistan

The increasing reliance on software and digital technologies has significantly changed how architecture is taught and practiced(Masdeu, 2022). This shift necessitates a more human-centric approach to architectural education that leverages technology to enhance the learning experience and nurture well-rounded, critical thinkers.

This strategy plan's transformation of design studio education represents an exciting and intriguing prospect. One particularly captivating aspect is the emphasis on a decentralized model of education, with a focus on both in-school and remote learning opportunities. This shift from the traditional centralized approach suggests a more flexible and adaptable framework better suited to today's students' diverse needs and learning styles. Further more, the dilution of boundaries between academia and the professional field is an element that piques interest. Establishing continuous and collaborative relationships, such as through consultancies, speaks to a more integrated and synergistic approach to design education. This interconnectedness between the classroom and the real world promises to better prepare students for the challenges they will face in their future careers while fostering a more dynamic exchange of ideas and innovations. The role of the teacher as a mentor and colleague is also a compelling aspect of this transformation. The notion of teachers guiding students through the design and fabrication processes and providing advice, sponsorship, and resources suggests a more personalized and supportive learning environment. This shift from a traditional, hierarchical model to a collaborative partnership can cultivate a more profound sense of student engagement and ownership, empowering them to take on an

entrepreneurial role in their projects and investigations.

Transformative Pedagogy Framework for Architecture

The central principles outlined in this framework represent a holistic approach to transforming architectural pedagogy in Pakistan. By embracing challenges as growth opportunities, students are encouraged to view obstacles as catalysts for personal and professional development, fostering a resilient and adaptable mindset. Integrating research and design ensures that creative solutions are grounded in rigorous, evidence-based inquiry, leading to more informed and impactful design decisions.

The emphasis on collaborative exploration cultivates a community of learners, where peer-to-peer interaction and shared learning journeys enhance the educational experience. This collaborative approach balances academic rigor with creative freedom, allowing students to pursue individual visions within structured frameworks and guidelines. Finally, the principle of technology as a tool, rather than a constraint, empowers students to harness digital tools to amplify their design capabilities and facilitate innovation. By offering courses that teach advanced software as a means to an end, rather than an end in itself, the framework enables students to control technology in service of their creative vision. When implemented holistically, these central principles have the potential to transform architectural education in Pakistan, fostering a culture of critical thinking, collaborative problem-solving, and technological fluency to address the evolving challenges of the field.

The proposed core curriculum elements outline a comprehensive approach to transforming architectural education in Pakistan. The foundation skills courses aim to equip students with essential technical proficiency before engaging in more complex design projects, ensuring a solid technical foundation. On the other hand, the digital sherpa workshops leverage peer-to-peer learning, allowing experienced students or alumni to mentor others on advanced software and techniques, fostering a culture of knowledge-sharing and collaborative skill development.The parametric design and innovation labs provide dedicated spaces for students to experiment with cutting-edge digital tools, such as Unreal Engine, and push the boundaries of what is possible in parametric design. This allows for a more explorative and innovative approach to design, potentially leading to novel solutions.

The research-driven studio projects are particularly noteworthy, as they require students to simultaneously apply rigorous research and creative design, ensuring that academic inquiry informs every stage of the design process. Integrating research and design is crucial for grounding creative solutions in evidence-based inquiry, leading to more informed and impactful design decisions.

The resilience training modules and activities are essential for fostering a mindset of adaptability and perseverance among students, equipping them with the necessary skills to navigate the uncertainties and challenges inherent in the architectural field. Finally, the regular reflection and feedback sessions aim to enhance self-awareness, iterative learning, and continuous improvement in design processes, fostering a culture of critical analysis and self-evaluation.

The implementation plan for the transformative pedagogy framework in architecture education is structured in four phases. Phase 1, the Preparation phase, involves a thorough curriculum assessment to identify gaps in digital tool training, research integration, and collaborative methodologies. This is followed by capacity building for instructors through professional development programs that immerse faculty in new digital tools and innovative teaching methods. A repository of tutorials, guides, video content, and peer-generated materials is also been developed to support self-paced and supplementary learning.

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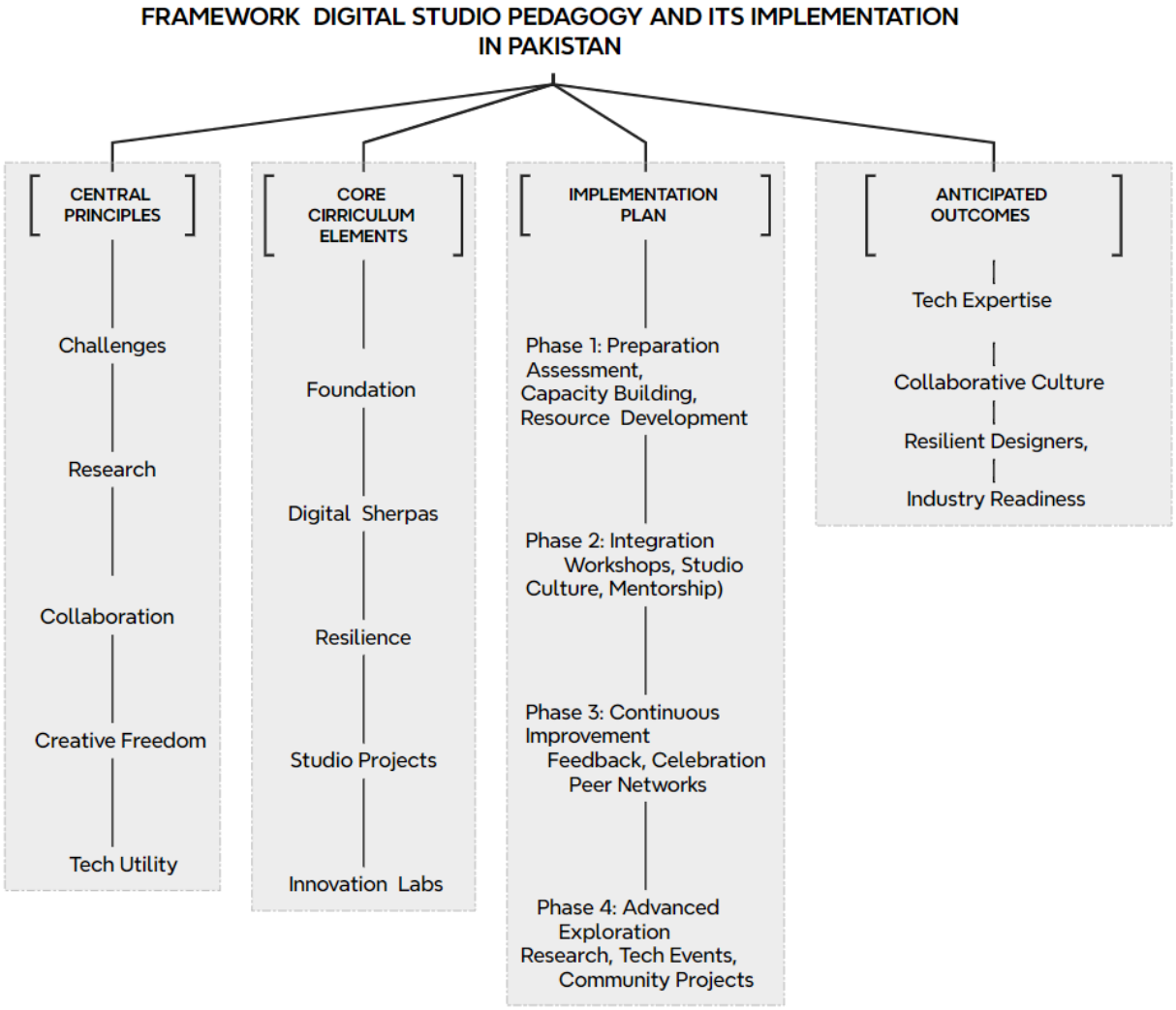

Figure 2- Framework for digital studio pedagogy and its implementation in Pakistan (Author)

The Integration phase, Phase 2, begins with introductory workshops focused on software mastery and design thinking, setting a solid foundation for subsequent explorations. This phase also emphasizes cultivating a collaborative studio culture, where studio projects are structured around team-based challenges, ensuring that all students experience leadership and collaboration. Furthermore, bi-weekly reflection sessions and mentorship meetings are established, enabling students to discuss challenges, share insights, and receive constructive feedback from peers and instructors. The Continuous Improvement phase, Phase 3, involves continually implementing regular feedback collection mechanisms to refine pedagogical approaches. Periodic exhibitions, presentations, or digital showcases are organized to celebrate student achievements, reinforcing the value of both process and product. Additionally, lasting platforms are created where advanced students can guide newcomers, ensuring sustained learning beyond the classroom. Finally, the Advanced Exploration phase, Phase 4, encourages students to author papers, blogs, or presentations documenting their design research and methodologies, contributing to the broader academic community. Technology for Creativity events, such as hackathons, design-a-thons, or competitions focused on innovative uses of technology in design, are hosted to stimulate creative problem-solving. Moreover, community engagement projects are initiated,

collaborating with local communities or industry partners to ground academic exercises in practical impact. Through this phased implementation plan, the transformative pedagogy framework aims to create a comprehensive, iterative, and sustainable approach to architectural education in Pakistan. It aims to foster a new generation of design professionals equipped with the necessary technical, collaborative, and critical thinking skills to address the evolving needs of the built environment.

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