



Contents lists available at <http://qu.edu.iq>

Al-Qadisiyah Journal for Engineering Sciences

Journal homepage: <https://qjes.qu.edu.iq>



Learning challenges of architectural education in early twenty-first century: A systematic literature review

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ARTICLE INFO

Article history:

Received 00 January 0000

Received in revised form 00 February 0000

Accepted 00 May 0000

Keywords:

Architectural Education

Learning Approaches

Technology Innovation

Sustainability

History

PRISMA

ABSTRACT

Architectural Education (AE), as a multidisciplinary realm of knowledge, has undergone diverse pedagogical transformations, incorporating different learning theories and concerns to adapt to the evolving educational landscape and the escalating demand for a sustainable built environment. This comprehensive investigation of the literature intends to present the most dominant challenges and examine trends in AE in the first few decades of the twenty-first century. The review framework applied by the authors is the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA). The authors searched keywords in the Scopus and Web of Science (WoS) databases, investigating ninety-six articles published between 2000 and 2023, and implementing the inclusion and exclusion criteria. The analysis of the relevant articles has provided valuable insights into research intention, revealing several main themes in the AE: learning approaches, technology innovation, sustainability, history, students' experience and performance, architecture design and design studio, society concerns, computer application in AE, architecture curriculum, and Building Information Modelling (BIM). The review also found that researchers identify the efficiency of several teaching strategies primarily used at architectural schools include experiential, online, e-learning, and blended learning. This interpretation of predominant architectural issues and learning challenges will significantly enhance the learning environment by providing guidelines for integrating advanced technological tools, effective learning methodologies and practical experience. International collaboration among academic staff in the field of architecture is crucial for the thorough evaluation of literature on the AE. Engaging architecture professionals from around the world will effectively help overcome linguistic and societal barriers. The study suggests that more research on art, social context, and the physical built environment is crucial for enhancing AE.

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1. Introduction

1.1. Background of AE

Throughout history, we have witnessed massive infrastructure construction dedicated to protecting and serving communities. Despite the scarcity of records on architecture education and practice, the remaining historical sites and monumental buildings are a testament to the remarkable skill development in arts and architecture. To illustrate, the sculptural

representation of Gudea, an ancient Mesopotamian ruler of Lagash and distinguished Neo-Sumerian king (2144-2124 BCE), stands as an exemplar artefact underscoring AE and professional pursuits, as portrayed in Fig.1[1]. Gudea is renowned for his prowess in artistic pursuits and acumen in designing religious edifices[1]. Fig.1 further elucidates architectural schematics near the ruler, complemented by precision measuring instruments.

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<https://doi.org/10.30772/qjes.00000.0000>

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The architectural styles across different countries are shaped by several variables, notably the climate, culture, and socio-economic context. Specific educational and professional practice principles and standards guide architects. A renowned Greek architect, Vitruvius laid out these principles in his book "Ten Books of Architecture"[2]. In his first volume, he stressed the significance of architects' expertise in drawing, geometry, art, history, medicine, philosophy, physics, music, mathematics, climate, and water[2].

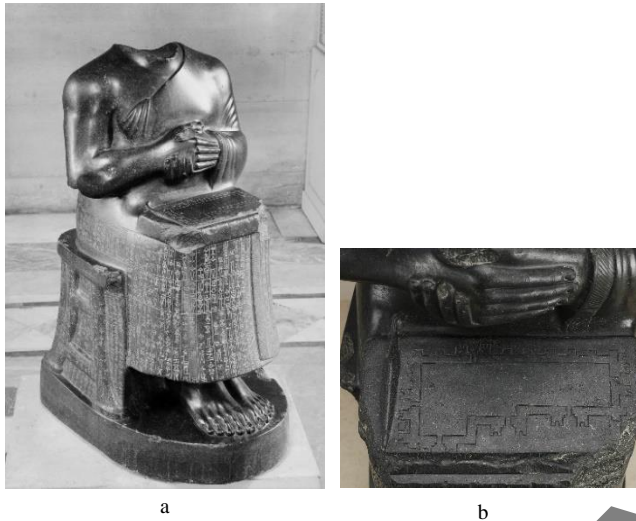


Figure 1. (a) The Sculpture of Gudea ruler of Lagash; (b) the plan for a new religious building with architectural drawing tools adopted from Collections. Louvre[3].

1.2. AE as Higher Education

The Academie d'Architecture, founded in 1671 in Paris, was the first educational institution dedicated to architecture[4]. However, the school was closed due to the French Revolution. Subsequently, the Ecole de Beaux Art and The Ecole Polytechnique were established, significantly impacting the profession of architecture and AE worldwide[4]. Atelier practice, a form of hands-on learning, is French architecture schools' primary education mode. These developments profoundly influenced the architectural profession and AE globally[5]. The prevalent atelier practice in French architecture schools emerged as a dominant learning form. Afterwards, in the late 19th and initial 20th centuries, architecture schools sprung up on every continent of the world. In the 1930s, the German architectural groups pioneered the Bauhaus teaching methods[6], marking a transformative shift in AE from a professional practice to a community academy. The studio-based learning approach, integral to the Bauhaus architecture school, has since become a global fundamental subject in architecture schools. Nevertheless, critiques emerged, asserting that design studios often operate isolated from real-world contexts, emphasizing theory over experiential learning[7]. In the last century, academics and architects have expressed a variety of perspectives, issues, and theories in architecture education.

The advancement of technology, growing environmental concerns, and social reforms have significantly impacted the AE and architecture profession in the 21st century. Of these, environmental concerns have emerged as a crucial factor, in shaping the future of architecture. Several architecture community organizations, including the Union International Architecture (UIA), have established guidelines to support this field's development. They have suggested fundamental principles and guidelines for the AE at a global level, emphasizing the importance of collaboration among architecture schools and professionals on a larger scale[8]. Consequently, the expanding body of literature on AE has undergone significant diversification in recent years, reflecting the multidisciplinary nature of architecture and posing challenges to achieving clear and comprehensive insights in delivering AE. Most of the contemporary research, even literature reviews, are dedicated to certain concerns that could be related to, or influence AE. Thus, the authors touch upon the issues of immersive technology and its role in shaping AE [9] or review the standard signs of healthy architecture inbuilt space[10]. Professional development in architecture is an ongoing necessity for both architects and educators due to various complex factors affecting the practice and pedagogy of architecture. This systematic review of the most disseminated articles aims to consolidate current knowledge on AE and discern critical issues and pedagogical approaches in architecture.

2. Research Methodology

The authors employed a structured methodological approach guided by Shaffril et al. (2021) to ensure a comprehensive synthesis of existing literature on AE worldwide. The study involved several essential steps. Firstly, they developed a review protocol. Secondly, they delineated the research question and identified keywords. Thirdly, they outlined the research strategy, which included seeking sources in two prominent electronic databases: Scopus and WoS. The inclusion criteria specified that published articles should be in English and cited between 2000 and 2023. The text then proceeds to provide details regarding the search process, data extraction, and synthesis of outcomes. The use of the PRISMA template was instrumental in facilitating the comprehensive reporting of individual steps in the search process and their respective outcomes, ensuring transparency and adherence to best practices[11].

2.1. The development and validation of the review protocol

The reviewers aim to examine the evolution of AE during the early 21st century, focusing on the most widely discussed issues and educational methodologies by researchers and architects on a global scale. The reviewers adopted a standardized review protocol to analyze existing literature and present AE's most researched concerns and learning methods. To accomplish this, they utilized the PRISMA- 2020 statement, which provides a comprehensive 27-item checklist for the review process[11]. It is worth noting that while PRISMA 2020 was initially designed for systematic reviews of health interventions, it has since seen application in other social sciences[12]. This research framework offers a meticulous and comprehensive approach to the review process[11].

2.2. The articulation of research query

The research inquiry was formulated using the Population, Intervention, Comparison, and Outcomes (PICO) framework. This review systematically addresses the following research inquiry: What were the predominant learning challenges and issues within AE during the early decades of the twenty-first century? The outcomes of this investigation hold significant importance for the critical evaluation and enhancement of the efficiency of various learning modalities in AE, with a specific focus on discerning the strengths and limitations inherent in each approach, particularly within the context of design studio sessions. Thus, by adopting the PICO formulation framework, populations were AE, the intervention of interest-dominant AE issues. No restriction was placed on the control/comparator; the outcome was learning and teaching challenges (as highlighted in Appendix A).

2.3. Systematic searching strategies

The systematic literature review adheres to the PRISMA 2020 protocol, encompassing three primary processes: Identification, Screening, and Inclusion refer Fig. 2. This structured methodology facilitates a systematic literature review characterized by reproducibility and transparency.

2.3.1. Identification

- Selection and enriching the selected keywords

To initiate the process of identifying credible sources to address the

research question, the authors identified a series of keywords and their relevant synonyms rooted in the research query. A search strategy was subsequently formulated based on specific inclusion criteria, guided by the PICO concept. The primary keywords consisted of Learning, Teaching, and AE. The authors consulted a range of online resources, such as thesaurus.com, cross-referenced prior studies, and considered suggestions from Scopus and WoS databases to augment this lexical framework. This iterative process resulted in an expanded set of keywords, which included Learning, Teaching, Schooling, Studying, Training, Coaching, Tutoring, Guidance, Instruction, and Reading. Additionally, various synonyms for AE were incorporated, such as architecture education, architecture curriculum, architecture pedagogy, architecture syllabus, architecture modules, architecture studies, architecture schedule, architecture subjects, and architecture educational programs. The integration of these keywords was subjected to search functions, which included field code functions, phrase searching, wildcards, truncation, and Boolean operators across the two databases, i.e. the Scopus and WoS. The authors then developed a search string for references as shown in Table 1. The Scopus and WoS databases were inspected, and 707 initial sources were identified. However, after applying predefined inclusion and exclusion criteria, a further refined set of ninety-six journal articles were selected for the review as demonstrated in fig. 2. Initially, the authors include only written articles in the English Language to avoid misunderstanding text content due to improper non-English language skills.

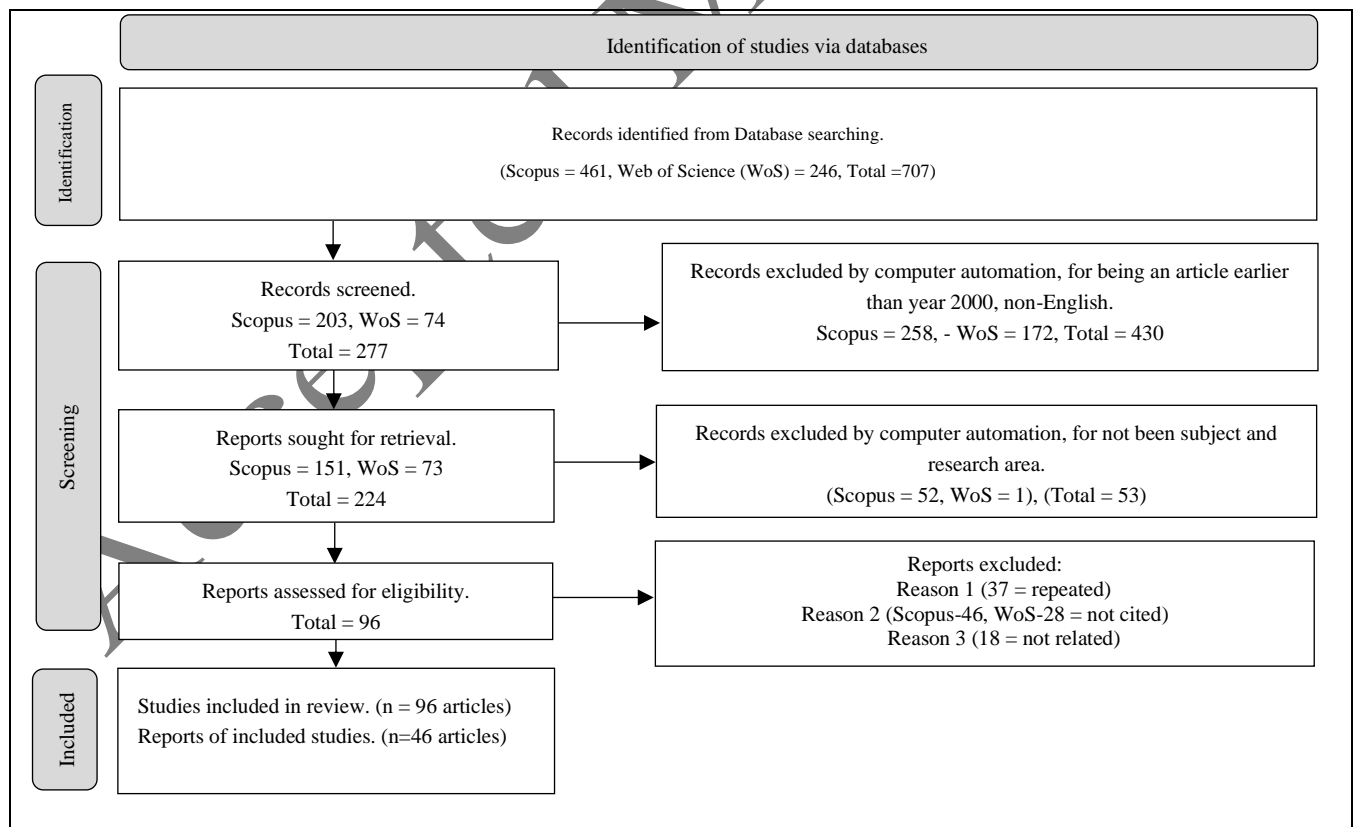


Figure 2. The Review PRISMA Flow- (Source: Adapted by authors).

Table 1. The search string used in the selected databases (Source: Authors)

Database	Search string	Number of articles
Scopus	TITLE (("learn*" OR "teach*" OR "school*" OR "study*" OR "train*" OR "coach*" OR "tutor*" OR "guidance" OR "instruction" OR "read*") AND ("Architectur* Education" OR "architecture curriculum" OR "architectur* pedagogy" OR " architectur* syllabus" OR "architectur* modules" OR "architectur* studies" OR "architectur* schedule" OR "architecture* subjects" OR "architecture* educational program")) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "ENGI") OR LIMIT-TO (SUBJAREA, "ARTS")) OR LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "MULT") OR LIMIT-TO (SUBJAREA, "PSYC"))	151
Web of Sciences	Results for TI =(("learn*" OR "teach*" OR "school*" OR "study*" OR "train*" OR "coach*" OR "tutor*" OR "guidance" OR "instruction" OR "read*") AND ("Architectur* Education" OR "architecture curriculum" OR "architectur* pedagogy" OR " architectur* syllabus" OR "architectur* modules" OR "architectur* studies" OR "architectur* schedule" OR "architecture* subjects" OR "architecture* educational program")) and Architectural Education (Should – Search within topic) and Architecture Education (Should – Search within topic) and Article (Document Types) and English (Languages) and 2023 or 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 or 2013 or 2012 or 2011 or 2010 or 2009 or 2008 or 2007 or 2006 or 2005 or 2004 or 2003 or 2002 or 2001 or 2000 (Publication Years) and Architecture or Education Educational Research or Engineering or Environmental Sciences Ecology or Urban Studies or Science Technology Other Topics or Art or Construction Building Technology or Computer Science or Social Sciences Other Topics (Research Areas) and Open Access	73

- Selection of databases

The reviewers conducted a search on the WoS and Scopus electronic bibliographic databases to identify relevant journal articles. The two scientific databases have been widely used by researchers in various fields of knowledge[12]. Given the multidisciplinary nature of architecture, numerous articles related to AE were published since the early twenty-first century. Statistical data obtained from the Scopus database reveals a clear and consistent upward trend in the availability of resources within the discipline of AE. Specifically, the number of documented sources in Scopus database has gradually increased from 1,044 in 2000 to 1,560 in 2010, and 2,009 in 2020, underscoring the constant growth in published references relevant to AE. The WoS and Scopus accurately identified the keywords related to AE in journal article titles. However, searching more databases and looking beyond just the article titles may retrieve additional literature that is irrelevant to AE or may be repetitive.

2.3.2. Screening

The screening process, constituting the second phase of the systematic literature review in adherence to the PRISMA protocol involved delineating articles for either inclusion or exclusion. The authors facilitated this determination through database-assisted screening and manual assessment, as elucidated in Fig. 2. The screening process consisted of three sequential steps, each of which was methodically executed to ensure the highest level of accuracy. Initially, the authors considered only published articles within the temporal span of the years 2000 to 2023 and that were written in English, in alignment with the research question. This step automatically excluded 258 articles from Scopus and 172 from the WoS databases. Next, the authors focused on specific subject areas and research areas related to the AE, as delineated in Table 2, and excluded another fifty-two articles from Scopus, and 203 from WoS. Finally, the reviewers employed manual inspection to distinguish prevalent challenges in AE within the extant data, by meticulously eliminating redundant, non-cited, and unrelated articles resulting the list of ninety-six articles subjected to eligibility analysis. The inclusion and exclusion criteria details are presented in Table 2, providing transparency and clarity.

Table 2. Demonstration of the inclusion and exclusion criteria. (Source: Authors)

Criteria	Inclusion	Exclusion
Timeline	2000-2023	1999 and earlier
Document Type	Cited Articles	Non-cited articles, chapters in a book, conference proceedings
Language	English	Non-English such as Turkish, Chinese
Subject Area	Scopus: Social Sciences, Engineering, Arts and Humanities, Environmental Science, Multidisciplinary, Psychology	Computer Science, Energy, Medicine, Material Science, Mathematics, Psychology, Chemistry, Health Professions, Chemical Engineering, Decision Sciences
Research Area	Web of Science: Architecture, Education, Educational Research, Engineering, Environmental Science Ecology, Science Technology Other Topics, Art, Urban Studies, Construction Building Technology, Social Sciences Other Topics, Sociology	Computer Science, Energy, Medicine, Material Science, Mathematics, Psychology, Chemistry, Health Professions, Chemical Engineering, Decision Sciences Chemistry, History, Sociology, Archaeology, Linguistics

3. Results

This study presents a comprehensive overview of the research process of searching for relevant literature on AE learning challenges. The PRISMA flow diagram Fig. 2 succinctly delineates the search process across databases, which yielded 96 potentially relevant studies regarding the AE. This paper systematically identified ten overarching themes, along with corresponding sub-themes, to identify learning challenges in AE, which encompass various areas such as learning approaches, technology innovations, sustainability, history, students' experience and performance,

architectural design and design studio, culture, community and societal concerns, computer applications, architecture curriculum, and (BIM) (Table 3). The authors identify the themes after analysis of the title, abstract, content and conclusion of the related articles based of inclusion criteria. Despite the inherent overlaps among these themes, the literature predominantly focuses on the main themes and learning approaches used in AE during the early decades of the twenty-first century. It is worth noting that this study's findings provide valuable insights into the learning challenges in AE and can serve as a valuable resource for professionals and researchers in this field.

Table 3. The main themes of the AE during the early twenty-first century were based on the literature review (Source: Authors).

Number	Main themes	Number of articles in review	Ratio
1	Learning Approaches	27	28.4 %
2	Technology Innovation	12	12.6 %
3	Sustainability	10	10.5 %
4	History	10	10.5 %
5	Students' Experience and Performance	9	9.5 %
6	Architectural Design and Design Studios	9	9.5 %
7	Culture, Community and Society Concern	7	7.4 %
8	Computer Application	3	3.2 %
9	Architecture Curriculum	4	5.3 %
10	BIM	3	3.2 %

Table 4. A comprehensive overview of the prevalent learning approaches in AE. (Source: Authors)

4. Findings

The realm of AE is a multidisciplinary field, and as such, a wide array of literature exists on the subject. Review of this literature has led the reviewers to identify ten distinct themes, which are categorized and presented in Table 3. Most of the articles surveyed (27 articles) focus on the learning approaches utilized in AE and their efficacy. Meanwhile, integrating technological innovation (12 articles) into AE constitutes the second most common focus of study. Conversely, topics such as materials, structure, and urban design received less attention from researchers and were therefore excluded from this study.

The scholarly reviewer in this study underscores the progression of AE literature during the early decades of this century, as depicted in Fig. 3. Utilizing the PRISMA analysis framework, it is evident that topics about learning approaches, technology innovation, sustainability, history, students' experience and performance, architecture design and design studio, society concerns, computer application in AE, architecture curriculum, and BIM. The paper revealed that innovative technology and history consistently dominate discussions within AE, signifying their interconnectedness with AE. The emergence of sustainability studies in AE during the second decade mirrors the community's call for integrating sustainability into the architecture curriculum (Fig. 3). Furthermore, the widespread dissemination of learning methodologies in AE from the latter

half of the second decade onward reflects the adoption of diverse learning approaches, including experiential learning, blended learning, E-learning, online learning, and project-based learning (Fig. 3), which indicates the intent of architecture schools to enrich student engagement and motivation by leveraging innovative technology and incorporating additional practical sessions.

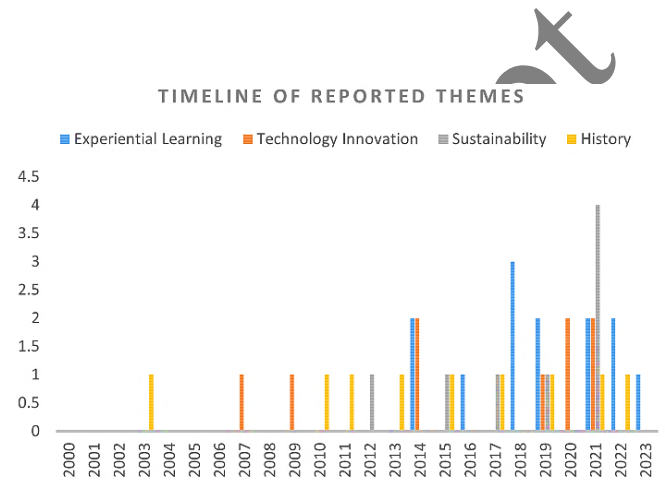


Figure 3. The timeline of highlighted themes in review (Source: Authors).

In addition, the bibliometric analysis of the included articles shows that only nine authors are collaborating on studying issues related to AE (Fig. 4). A term co-occurrence map based on the title and abstract of the analysed articles reveals the rich diversity of AE, with four main issues emerging: AE, architectural study, architectural design, and implementation (Fig. 5). This diversity showcases the breadth of the field and can inspire scholars to explore new areas of research. However, it's also notable that the art and social-related concerns and practical aspects of architecture do not appear as fundamental parts of the AE, suggesting potential area for further exploration.

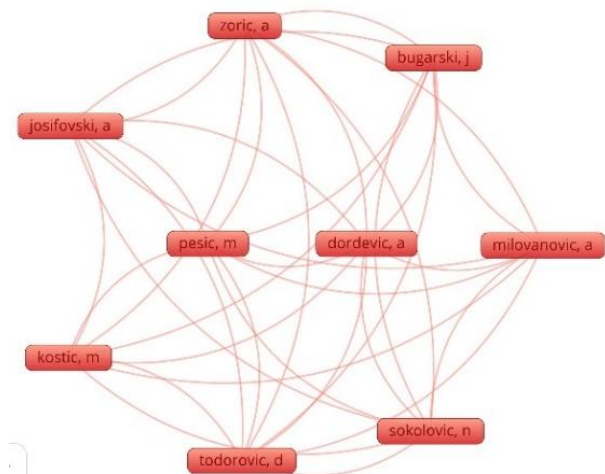


Figure 4. The visual network of co-authorship of included articles. (Source: Authors adopted from VOS viewers).

Several studies have confirmed that experiential learning increases students' motivation[15] and learner experience[16, 17]. This approach offers substantial opportunities for architecture students to glean insights from the urban environment[18], engage in collaborative activities with local communities[19], participate in live projects, and gain individual perspectives from community members[17]. Consequently, service learning has emerged as a prominent theoretical framework in numerous studies, often coupled with qualitative research methodologies (Table 5).

Table 4. A comprehensive overview of the prevalent learning approaches in AE. (Source: Authors)

Number	Main themes	Number of included articles in the review
1	Experiential learning	8
2	Blended Learning	3
3	E-Learning and Online Learning	3
4	Project-based learning	2
5	Augmented Reality	2
6	Virtual Reality	2
7	Collaborative Learning	1
8	Aesthetic Cognition and visual skills	2
9	Expansive Learning	1
10	Integration of Technical course	2
11	Hybrid Learning	1

4.1.2 Blended Learning

In contemporary architecture education research, the efficacy of blended learning methodologies has been scrutinized (Table 6). Several scholars have presented studies on this topic. An outstanding illustration is the work of Megahed and Hassan (2022), who proposed a novel framework for implementing blended learning in AE using various research techniques during the COVID-19 pandemic. Jasiołek et al. (2021) devised an innovative hybrid educational model based on a survey of architecture

students at a Polish university. In addition, some researchers have demonstrated the significance of blended learning in AE in exploring challenges of architecture practice, communication skills and students' perception. Rodrigues et al. (2016) studied a shared actual project between two universities from different countries (Columbia and England) that integrated face-to-face and distance interaction among students, academic staff and other experts. They stated that students can collaborate effectively and enhance their confidence in their abilities when placed in a natural environment[20].

Furthermore, Rauf et al. (2021), through an analytical and literature-based inquiry, posited that integrating virtual reality with in-person, real-world experiences would enhance students' performance and engagement in the AE process. Those contributions collectively contribute to a nuanced understanding of the potential advantages and applications of blended learning in the AE landscape[22].

4.1.2. E-Learning and Online Learning

The integration of e-learning and online education into the academic systems of schools and higher education institutions has been expedited by digital technology and communication infrastructure advancements. This acceleration has been especially notable in emergencies such as the global COVID-19 pandemic, particularly during the third decade of the 21st century. Numerous researchers and educators have examined the characteristics and effectiveness of these learning modes as alternative or supplementary components of the learning process from various perspectives (Table 6). Empirical evidence from experimental research conducted by Xiberta et al. (2022) highlights the positive impact of e-learning platforms, such as SAPIENS, on students' performance, promoting equitable opportunities in the AE[24]. Describe online workshops as innovative pedagogical approach during periods of emergency disruption, revealing both this methods' learning potentials and limitations within architecture schools[25].

Table 5. A thematic analysis of the experiential learning research approaches and outcomes. (Source: Authors)

Author/s	Research method	Research design	Deductive code	Research outcomes
Mackintosh (2014)	Qualitative	Ethno-methodological approach Transformative learning	The transformative learning experience.	The development of a pedagogical framework for AE[16].
Yazici and Töre (2014)	Mixed method	Case study project -Open-ended questions	Students' use of urban design information.	Students possess the capability to extrapolate knowledge and facets of urban design to smaller scales within the design domain[18].
Ňitavská et al. (2016)	Qualitative	Interviews	Connecting municipal planning and landscape research for better urban planning.	The university gained an enhanced understanding of pertinent issues, providing local governments with scientifically substantiated information to facilitate more judicious decision-making[19].
Mulligan et al. (2018)	Qualitative	Focus group and Individual inter-view	Students' perception of inclusive design.	Students' motivation to understand disability requirements increases with a transformative shift towards inclusive design[15].
C.M. Rodriguez (2018)	Qualitative	Experiential learning	Identification of live project value alongside studio-based project.	Significant understandings of the advancement of intellectual, physical, and emotional facets are gleaned from these encounters[7].
Gregory (2019)	Qualitative	Service-learning courses.	Service-learning and social justice in architecture.	Social justice in service-learning courses enhances reflective analysis and critical thinking, providing a comprehensive understanding of social issues[17].

Table 6. An illustration of a thematic analysis of the blended learning research approaches and outcomes. (Source: Authors)

Author/s	Research method	Research design	Deductive code	Research outcomes
(Rodriguez et al., 2016)	Qualitative	Two case studies	Distance learning in real projects.	Students showed impressive collaborative skills and developed self-confidence by actively participating in real-life projects[20].
(Jasiolek et al., 2021)	Qualitative	Survey	Criteria for a new, effective mode of AE with student input.	A new hybrid mode of education[21].
(Rauf et al., 2021)	Qualitative	Analytic and literature-based research	Combination of virtual reality and face-to-face experience.	Enhanced students' outcomes and engagement[22].
(Megahed & Hassan, 2022)	Mixed method	Online surveys, semi-structured interviews, observation	New hybrid mode	A theoretical framework for a blended learning strategy to reimagine education post-COVID-19[23].

Additionally, Olweny et al. (2023) delve into online student education across two East African institutions, examining accessibility, equity, and adopted learning strategies. The study suggests recommendations for refining the learning process based on students' experiences and attitudes toward online education within the same context[26]. It is worth noting that most studies emphasize the potential advantages of e-learning and online learning, along with the challenges of technical and administrative complexities, academic evaluation intricacies, and faculty engagement. This trend indicates that e-learning and online learning will become increasingly integrated and significant in the landscape of architecture schools.

4.2. Technology Innovation

The discourse on AE has undergone significant development, with nuanced discussions on the challenges and potential of technological innovation in the pedagogical framework. These discussions encompass communication facilitation and learning tools, with articles that expound on innovative technical ideas and tools commanding considerable citations and symbolizing the ongoing dialogue within the architectural discipline (Table.8). According to Wang (2009), the effective deployment of technology for information and communication within AE is a potent catalyst for fostering collaborative efforts among architecture schools on a global scale. Similarly, Schnabel and Ham (2014) elucidate that incorporating social cloud adaptation methodologies into architectural

curricula contributes substantially to learners' engagement and performance. Saghafi and Crowther (2021) underscore the pivotal role of the technology in design studio sessions, seamlessly integrated to enhance students' outcomes and skills.

In addition to these educational considerations, innovative technological tools and concepts find application in investigating and enhancing building envelopes and environments which is beneficial in the design process and examining the condition of the existing built environment. Milovanović et al. (2020) underscore the significance of numerical modelling and analysis in discerning structural performance and vulnerability conditions in monumental historical buildings. Sahai and Varshney (2021) contributed to the domain by identifying a prototypical geometrical form and size of plasmonic nanoparticles, thereby optimizing the performance of organic-inorganic halide perovskite solar cells. Furthermore, Song et al. (2018) expounds on pivotal role of 3D printing technology in design studios, delineating its significance while acknowledging its limitations through practice-based research within the AE domain. However, the shortfall in

Table 7. A demonstration of a thematic analysis of the E-learning and Online learning research approaches and outcomes. (Source: Authors)

Author/s	Research method	Research design	Deductive code	Research outcomes
(Xiberta et al., 2022)	Quantitative	Questionnaire	SAPIENS tool application in AE	A noteworthy variation was observed among different test formats, with distinct responses from various groups. Notably, individual experiences did not exhibit any discernible impact on test scores[24].
(Milovanović et al., 2020)	Mixed method	Questionnaire	Online Workshops in AE	Challenges as an application of research by designing methodology and problem-based learning. The second question was answered through the educators' constant awareness and endeavours to be informed about essential global topics and to convey profound insights from research and practice to education in emergency architecture[25].
(Olweny et al., 2023)	Quantitative	Questionnaire	Online architectural education	Offered a series of recommendations for the implementation of online learning[26].

digital design courses within AE, as identified by Abdullah and Hassanpour (2021), is a significant gap that needs to be addressed.

sustainability into the architecture curriculum, as underscored by Brzezicki and Jasiolek (2021) and Pektas et al. (2015).

Table 8. A delineation of the thematic analysis of research about technology innovation within the context of AE. (Source: Authors)

Author/s	Research method	Research design	Deductive code	Research outcomes
(Angulo, 2007)	Mixed method	Case studies	Digital media role in AE	New opportunities and challenges are expected from evolving multimedia design environment[30].
(Wang, 2009)	Qualitative	A brief literature review	Information and communication technology	Emphasis is on collaborative efforts between students and educators, optimizing such utilization for the AE[31].
(Schnabel & Ham, 2014)	Qualitative	Case study	The Social Network Learning Cloud (SNLC)	The manuscript proffered methodologies for integrating the SNLC into curriculum and pedagogy, and offers guidance on its use in professional settings[32].
(Song et al., 2018)	Qualitative	The practice-based research	3D Printing technology	Examining the status of 3D printing technology in education is helpful in anticipating limitations and informed decisions[33].
(Fortenberry, 2019)	Qualitative	Structured collection of case studies	Digital media	Manuscript: Findings, opportunities, and challenges in multidisciplinary integration. Analysis based on multi-modal, media-rich design[34].
(Higue-ra-Trujillo et al., 2020)	Mixed Method	A two-phase study: Qualitative and quantitative	Multisensory stress reduction	The beneficial effect of a combination of environmental satisfaction sources[35].
(George & Park, 2020)	Qualitative study	A department-wide drone programme	Drone technology	Although the program has exhibited both efficacy and enduring viability, various impediments necessitated resolution to attain this level of success[36].
(Sahai & Varshney, 2021)	Quantitative	Case study	Solar absorbance	Optimal augmentation can be achieved through the incorporation of spherical nanoparticles with a radius of 70 nm positioned at the central region of the film[37].
(Saghafi & Crowther, 2021)	Qualitative	A case study approach based on document analysis methods.	Integrating technology subjects	Iranian curriculum emphasizes theory, Australian curriculum emphasizes practical application in design studios[38].

4.3. Sustainability

The incorporation of sustainability principles into architecture curricula has emerged as a topic of significant scholarly discourse. This discussion has been particularly accentuated in recent years, owing to the concerted global efforts directed towards sustainability strategies. Amidst this backdrop, researchers and academic practitioners have engaged in comprehensive discussions concerning the most productive approaches and methodologies for incorporating sustainability into architecture education (Table 9), approaches and methodologies that are shaping the future of architecture field. For instance, Amer (2009) has elucidated the pivotal role of the Biomimetic Approach in augmenting student awareness of sustainability via biomimetic projects. Similarly, Xie et al. (2021) have contributed to this discourse by identifying the positive impact of the value-belief-norm theory on sustainability learning processes within universities in South China. In addition, scholars have conducted research to evaluate students' experiences and expectations regarding sustainability issues[27], assessment systems[28], and simulation measurement tools[29]. Simultaneously, scholarly discussions have delved into the theoretical frameworks and approaches governing integrating sustainability courses and issues into architecture pedagogy. However, some researchers posit that additional efforts are imperative for seamlessly integrating

4.4. History

Historical literature provides a detailed analysis of the developmental stages and intricacies of ancient religious structures and edifices (Table 10). The dissemination of historical literature on the AE takes a continuous trend which provides a detailed analysis of the developmental stages and intricacies of ancient religious structures and edifices. The scholarly inquiries can be grouped into three distinct categories based on their research outcomes. Firstly, some investigations delve into the retrospective exploration of structural elements and functional transformations within buildings. These studies are conducted concurrently with archaeological and restoration activities, enriching our understanding of historical constructions. For example, Gil Delgade (2013) meticulously identified the architectural elements of a synagogue and mosque during the restoration of the Santa Maria la Blanca church in Spain. Samol et al. (2021) provided evidence that the tower lighthouse in Gdansk underwent construction spanning six distinct historical epochs. Additionally, Blanke (2015) observed the evolutionary structural changes in the central bathing facilities in Gerasa, moving from expansive communal bathing areas to more compact individual washing spaces. Secondly, some studies elucidate historical built environments' unique architectural and design elements. Drancolli (2022) documented the Koca Sinan Pasha Mosque, highlighting

its structural virtues and interior intricacies. Correspondingly, Hagra (2019) examined the Xi'an Daxuexi Alley Mosque in China, expounding on how Chinese Islamic architecture seamlessly amalgamates Islamic cultural influences with the local heritage of China.

Thirdly, discussions revolving around establishing an appropriate framework for studying vernacular architecture exist. Davidson delved into a formalized study framework aimed at scrutinizing vernacular architecture, drawing insights from the works of scholars within the architecture discipline. Furthermore, Smith (2011) advocated for enhanced efficacy in adopting storytelling as a methodological tool in researching vernacular environments.

5. Discussion

The discourse surrounding AE is marked by a discernible proliferation of learning challenges, a testament to the multifaceted nature of architecture as a multidisciplinary field. These challenges, which shape AE as a multidirectional learning process, also have implications for architectural professionals, providing a lens through which to respond adeptly to evolving contexts in the built environment. The systematic literature review, a crucial tool in this understanding, serves as an insightful compendium of architects', researchers', and institutional communities' perspectives, particularly in the initial decades of the twenty-first century

The study presents an in-depth analysis of adverse event trends from 2000 to 2023 through implementing the PRISMA framework. Nevertheless, it is may architecture, the review process demands substantial time and effort. Including more than five or six reviewers from diverse architecture schools

globally may provide a more comprehensive perspective on adverse events. The study's findings are significant to architectural professionals and educators. It provides valuable insights that can guide these professionals integrating advanced technological tools, effective learning methodologies, practical experience, and diversity within the architecture discipline throughout the adverse event process.

6. Conclusion

The findings of the study highlight ten pivotal themes that have garnered considerable attention: learning approaches, technology innovation, sustainability, history, students' experience and performance, architecture design and design studio, society concerns, computer application in AE, architecture curriculum, and BIM. Notably, experiential, blended, e-learning and online learning have emerged as architectural academia's most scrutinized learning approaches. While historical studies and technology innovation challenges in AE continuously appeared in the early twenty-first century, sustainability and learning approaches emerged in the second decade. However, a discernible gap exists, necessitating further exploration into the integration of art skills, live projects, and social context within the domain of AE to enhance the holistic learning experience.

As the discourse surrounding learning approaches in AE intensifies, it becomes increasingly clear that subject-specific learning frameworks need to be critically appraised across diverse contexts to discern their efficacy and applicability. Moreover, the importance of collaboration among architecture schools on national and international scales cannot be overstated. Such collaborative endeavours are not just beneficial, but essential. They are envisioned to offer a more cohesive and direct

Table 9. The thematic analysis of research on sustainability within the realm of AE (Source: Authors)

Author/s	Research method	Research design	Deductive code	Research outcomes
(Pektaş et al., 2015)	Qualitative	Survey	Green Building Approach.	Proposed a collaborative project to bridge the gap between students' knowledge of green building practices in a developing and developed nation[28].
(Rieh et al., 2017)	Mixed method	An exploratory study	Sustainability-related course in AE	Sustainability education is structured variably concerning content, intensity, and sequence[39].
(Amer, 2019)	Quantitative	Questionnaire	Biomimetic approach.	A favorable impact of the biomimetic approach in professional practice[40].
(de Gaulmyn & Dupre, 2019)	Qualitative	Case study	Essay Approach for Sustainable and Environmental Design as Simulation Tool.	The findings indicated that solitary efforts lacked persuasiveness, while success was attained through collaborative group endeavors[29].
(Al Khalifa, 2019)	Mixed method	Survey, interview, and focus group	Incorporation of active learning pedagogy.	The student's involvement in the project improved their understanding of complex philosophical concepts in architecture and urbanism[41].
(Parra-Martínez et al., 2021)	Qualitative	Case study	Gender equality	Gender parity is vital in coeducational training for architects who shape innovative spatial design and material usage policies[42].
(Brzezicki & Jasiolek, 2021)	Mixed method	Survey	Students' Expectations vs. Experience of Sustainability	A substantial disparity exists between students' anticipations and actual encounters in sustainable and ecological design[27].
(Xie et al., 2021)	Quantitative	Survey	The value-belief-norm theory- Green building	The influence of biospheric and altruistic values can exert a direct impact on students' motivation to engage in the study of green building practices[43].
(Guerebarrena-Cortazar et al., 2021)	Qualitative	Documentary Analysis.	Integration of sustainability	The process of curricular transformation is gradual and inadequate, resulting in incomplete outcomes[44].

Table 10. The thematic analysis of the research objectives and outcomes of historical studies in AE. (Source: Authors)

Author/s	Purpose of research	Deductive code	Research outcomes
(Carletti & Giometti, 2003)	To elucidate and examine various wooden sculptures situated within the numerous churches of Pisa, Italy	Medieval wood Sculpture	In contrast to sculptures crafted from stone, wooden counterparts have consistently held a distinct function within liturgical practices, notably in the context of Sacred Representation[45].
(Erciyas & Çinici, 2010)	To ascertain the functional and historical context of the hexagonal basin located at Komana.	Architectural and arachnological study of the hexagonal basin at Komana.	Upon the culmination of our research endeavors, only one interpretation appeared plausible: a basin situated in a Christian Basilica, though certainty in this regard is not established[46].
(Smith, 2011)	To investigate the potential use of narrative elements and their impact on the study of vernacular architecture.	Narrative Prospect	Despite the notable attractions associated with it, the narrative approach can be intricate and less effective[47].
(Davidson, 2013)	To understand the future of vernacular architecture, it's important to study its intellectual origins.	Framework for Vernacular Architecture	The article contextualized an inconsistency in architectural history, brought together scholars who advocated eliminating the term vernacular and categorical distinctions, and established a foundation for a curriculum on global architects[48].
(Blanke, 2015)	To examine the architectural development of the Central Bathhouse.	Investigating the historical structures	The evolution indicated a shift in perspective from communal bathing in sizable basins to the practice of washing in individual basins[49].
(Dan & Herles, 2017)	To investigate the architectural structures uncovered in various archaeological sites throughout the kingdom of Urartu over several years.	Identification of architectural 'module' in Urartian culture	Identified the specific architectural module[50].
(Hagras, 2019)	The aim of this paper is to examine the design and architecture of mosques in Chinese.	Case study: XTAN DAXUEXI ALLEY MOSQUE	Chinese mosques have a unique architectural style that blends Islamic and traditional Chinese elements[51].
(Samól & Hirsch, 2021)	To identify the stages of constructional of the tower in Wisłoujście Fortress, in Gdańsk, during the conservation works.	Investigating the historical structures	Discovered six main stages of the structural construction[52].
(Drañçolli, 2022)	To learn about the mosque's challenges in the building's structure and decorations over time.	Religion Building: Koca Sinan Pasha Mosque	The research uses architectural visualizations and photographs to examine the significance of the mosque and promote it to wider audience[53].

channeling of efforts aimed at the global development and fortification of the architecture curriculum, thereby nurturing a more competent architect.

The research paper analyzed the trends in adverse events from early decades of century within the AE using the PRISMA framework. It is pertinent to acknowledge the limitations of the study, given its exclusive focus on cited articles, thereby omitting potential sources such as books and conference papers. Broadening the scope of keywords and engaging a more group of reviewers from different architecture schools could bolster the credibility of future research endeavors. The insights gleaned from the study are of significant value to professionals and educators in the field of architecture, offering a deep understanding of the integration of advanced tools, effective learning methodologies, practical experience, and diversity within the discipline amidst adverse events.

Authors' contribution

Both authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Appendix A

Search strategy.

Population: Architectural education

Intervention/exposure: dominant issues of learning and teaching

Comparison: Not restricted

Outcome: learning and teaching challenges

Generic* search syntax:

Population	Intervention	Comparison	Outcome
Architectural education	Dominant learning and teaching challenges	And [Any]	Learning and teaching issues

Generic * search filters:

Study design	Language	Date Range	Publication Type
Journal articles	English	20/2/2024	Journal articles

*Searches conducted 20th February 2024.

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