ICCAUA Proceedings Journal
Proceedings of the international conference of contemporary affairs in architecture and urbanism-ICCAUA
Volume 9 (December 2026), 2610019

Journal homepage: https://journal.iccaua.com/

DOI: https://doi.org/10.38027/ICCAUA2026EN0019

Mathematics in Interior Architecture Education in Türkiye: Curricular Positioning and Design Integration

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Received: 30.04.2026
Revised: 29.06.2026
Accepted: 01.07.2026
Available online: 10.07.2026

This article has been selected and peer-reviewed for publication in this journal as part of the 9th International Conference of Contemporary Affairs in Architecture and Urbanism, held on 7–8 May 2026 in Istanbul, Türkiye.

Abstract

This study examines the presence, content, and pedagogical positioning of “Mathematics” courses in undergraduate interior architecture programmes in Türkiye. As an interdisciplinary field, interior architecture relies on mathematics to shape both physical and perceptual aspects of space. A document analysis was conducted across 90 departments. The analysis followed three frameworks: Curricular Position Lens (GMC, DOM, POM), Conceptual Design Lens (MfD, MiD, MoD), and Thematic & Operative Lens. The findings identified 40 mathematics-related courses, evenly divided between compulsory and elective offerings. These courses are generally separated from design studios, with compulsory courses concentrated in early semesters and electives distributed across later years. Results show that mathematics is predominantly positioned as an instrumental and supportive element within curricula, while its role as a constitutive part of design thinking remains limited. The study argues that the key issue is not the presence of mathematics courses, but their epistemological positioning within design education.

Keywords: Interior Architecture Education, Curriculum Analysis, Mathematics Education in Architecture, Design Pedagogy, Mathematics Literacy.

1. Introduction

Interior architecture is mostly practiced within a clearly defined space. The concept of space has been described in different ways by various disciplines such as physics, mathematics, architecture, and philosophy. In the context of architecture, space is not only a physical environment, but also a mental and perceptual setting that shapes human experience. Mathematics can be a key tool to understand this complex spatial structure and the environment we live in (Sorguç, 2005). Architects and interior architects use mathematical thinking to design livable subspaces by organizing spatial geometry, proportions, and structure. Tangible output-based mathematical space models allow spatial analysis beyond intuition, fostering more objective and systematic design approaches (Arabacıoğlu, 2010). From the early stages of design to the discovery, shaping, and construction of forms, mathematics guides designers in identifying and implementing complex geometric structures. This has contributed to a transformation in aesthetic perception within architecture, revealing how many architects throughout history have consciously integrated mathematical structures and patterns into their designs. Mathematics is deeply integrated into every stage of the architectural design process. It spans abstract ideas like fractal geometry and topology, as well as tangible applications such as geometric algorithms and digital fabrication. It not only supports the creation of aesthetic forms but also ensures their physical feasibility and the efficiency of their production (Miranda, 2023). Design mathematics plays a crucial role in (interior) architecture education by enhancing students’ analytical thinking and problem-solving skills. By incorporating mathematical principles into the design process, students can develop a deeper understanding of how to create functional, sustainable, and aesthetically cohesive spaces while simultaneously fostering collaboration with other professionals. This integration of design mathematics can help reshape traditional practices and align the emerging values of interior design with more innovative, data-driven solutions. However, its integration into undergraduate curricula varies significantly across institutions.

This study explores the presence, content, and teaching methodologies of design mathematics courses in Türkiye’s interior architecture programs. By analyzing curricula and academic approaches, it identifies gaps and opportunities for improvement. The expectation that interior architecture education is oriented toward industry is unlikely to change in the short term. However, there are many opportunities to prepare future designers to bridge the gap between practice and values and to transform the current ecosystem. After high school education, students in Türkiye are evaluated through three different exam types: math & natural sciences (MS), science & verbal/Turkish equal weight (TM), and verbal/ Turkish & social science (TS). The Interior Architecture department admits students with the MS type, while the Interior Architecture and Environmental Design department admits students with the TM score type. Until 2017, some departments continued to admit students through talent exams. However, nowadays, students must take the Student Selection and Placement Examination (YKS in Turkish) to continue their undergraduate education. Interior architecture education varies significantly according to the schools' philosophy and pedagogy. Schools influenced by École des Beaux Arts focus on art/aesthetics, while technical universities like École Polytechnique follow a practical/technical-oriented pedagogy.

In this study, the status of "Design Mathematics" courses in Interior Architecture and Interior Architecture and Environmental Design Departments in Türkiye was examined by reviewing the Bologna data. The main aim of the study is to determine the current state of mathematics education in interior architecture training in Türkiye and examine its key objectives. This study provides a comparative perspective through a content analysis of design mathematics courses in interior architecture undergraduate programs in Türkiye. In this context, the following RQs were addressed:

RQ-1: What are the main objectives of mathematics education in interior architectural education? How are "Design Mathematics" courses presented in Interior Architecture undergraduate programs in Türkiye, in terms of content and approach?

RQ-2: What are the differences in "Design Mathematics" courses between departments admitting students with MS (math-science) and TM (equal-weight scores)?

Considering these questions, the study aims to provide a framework for the integration of "mathematics" into design education by identifying the current situation and making an original contribution to the literature.

1.1 Mathematics, Creativity and Architectural Space

The relationship between creativity, architecture and mathematics is a subject that has been discussed for years (Özcan & Akarun, 2001). The integration of creativity into mathematics and its relationship with design thinking has also been the subject of extensive academic and applied discourse (Shodiq, Juniati, & Susanah, 2025). Mathematical thinking competence is strongly linked to flexible problem solving and innovative engagement (Genc et al., 2025). This connection is also seen to feed into the architectural design process through the use of mathematics, whether theoretical or applied. The geometric perception and definition of space itself have formed the foundations of design geometry. Every period and trend in the history of architecture can actually be associated with the theoretical or practical application of mathematics. For example, the golden ratio in the search for beauty in the Renaissance period, "Existensminimum", "Taylorism", "Minimalism", etc., which emerged in the industrial revolution, emphasize the concepts of scale / proportion. With the separation of engineering and architecture specializations, the mathematics of architectural design has shifted from structural aspects to patterns, topologies, geometries, orientations and networks. Hence an increasingly quantitative approach to modularity, proportional relationships and environmental considerations. This quantitative approach has led to the transformation of architectural creation into an understanding based not only on experience but also on some tacit knowledge that can be transformed into computation (Başarır, 2022).

This relationship becomes particularly evident in iconic architectural works where mathematical reasoning directly shapes form and experience (Fig 1). Eero Saarinen's Gateway Arch, defined by a weighted catenary curve, demonstrates how structural optimization and symbolic expression can coincide through precise geometric formulation. Similarly, Louis Kahn's use of cycloidal geometry in the vaults of the Kimbell Art Museum reveals how mathematical curves regulate light, structure, and spatial atmosphere (Huylebrouck et al., 2007). In a different historical context, Mimar Sinan's mosque architecture reflects a comparable integration of geometry and spatial intelligence: in the Selimiye Mosque, each of the four slender minarets contains three separate staircases leading to three balconies, designed so that three individuals ascending simultaneously do not see one another until they reach the şerefe (balcony) (Arabacıoğlu & Arabacıoğlu, 2011). Across these examples, mathematics emerges not merely as a technical necessity but as a generative framework that informs architectural creativity and spatial imagination.

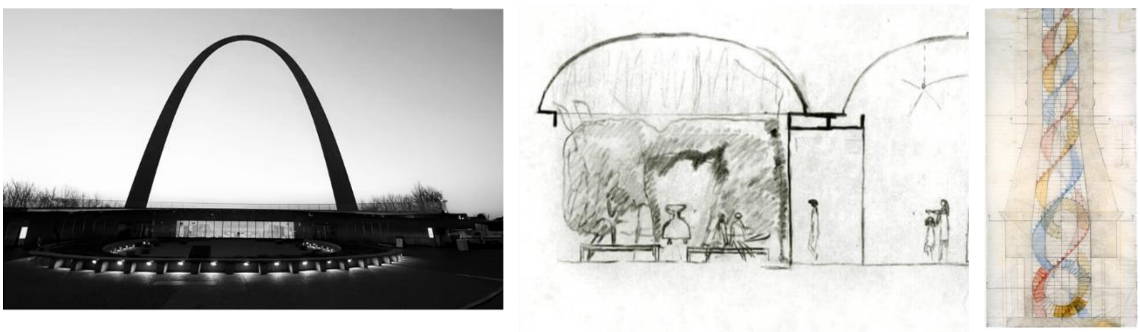

Figure 1. a. Gateway Arch by Eeron Saarinen Source: National Park Service, n.d. b. Kimbell Art Museum by Louis Khan Source: Kimbell Art Museum, n.d , c. Edirne Selimiye Mosque's Stairs by Architect Sinan Source: Sertöz, 2012.

The Möbius House, built by UNStudio in the Netherlands, exemplifies the thematic application of mathematics in architecture. Although it is practically impossible to literally transform a floor into a ceiling according to the Möbius strip, the Möbius curve operates as a diagrammatic and conceptual geometric reference (Boudon, 2024) (Fig. 2).

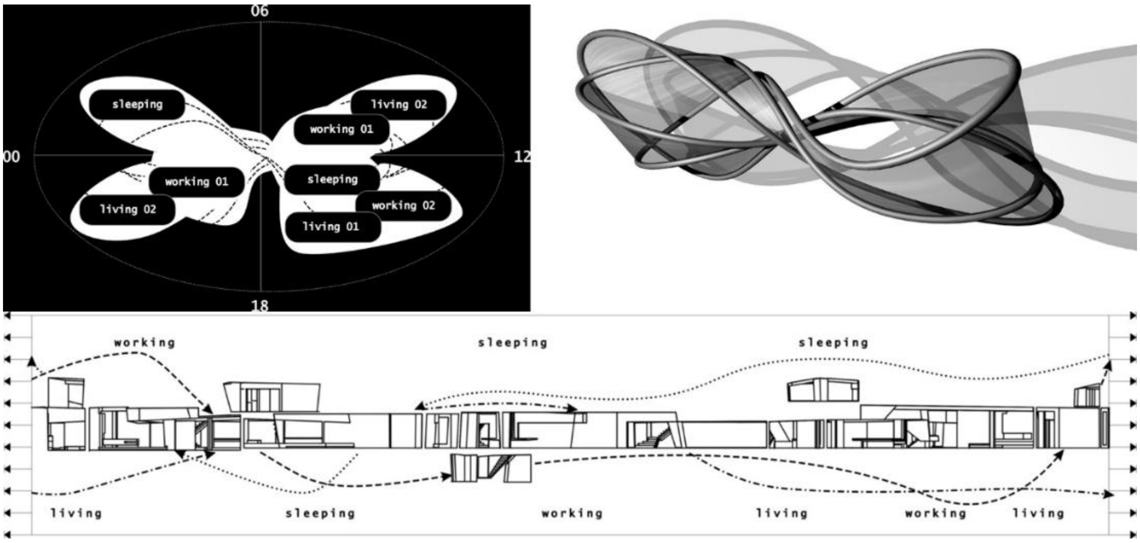

Figure 2. Mobius House, UNStudio. Source: Archdaily, 2024.

With the impact of the digital revolution, computational design and numerical technologies have further expanded the role of mathematics in architecture. Unlike earlier approaches, parametric design is not merely a tool for generating complex geometries; it establishes new possibilities for interdisciplinary collaboration across mathematics, computer science, and biology. Moreover, parametric thinking introduces a new level of complexity into architectural education, requiring a shift from intuitive pedagogical models toward more analytical and computational approaches. This transition enriches the design process and broadens its scope, prompting a reconsideration of architectural education itself (Günaydın Donduran et al., 2024; Oxman, 2006; Radziszewski & Cudzik, 2019). Integrating these emerging computational pedagogies with traditional architectural teaching frameworks enables the development of curricula capable of addressing both the intricacies of computational design (Mark et al., 2008) and the necessity for educators to continuously adapt to rapidly evolving technologies (Tucker-Raymond et al., 2021).Within computational design theory, the designer's interaction with the design object through digital representations, mathematical and logical models, rule-based systems, and algorithms further increases the complexity of the design process (Şen Bayram et al., 2023).
Recent studies further argue that mathematics in architectural education should not be limited to supporting geometric representation or computational production. Instead, mathematical reasoning is increasingly associated with algorithmic thinking, enabling students to understand design processes as rule-based systems rather than solely intuitive acts. Within parametric design education, the emphasis has gradually shifted from software proficiency toward the development of algorithmic reasoning and computational literacy (Vazquez, 2023). This transition suggests that mathematics functions not only as a technical skill set but also as a cognitive framework that supports contemporary design thinking.

1.2 Historical Overview of Mathematics Course Development

The historical proximity between architecture and mathematics demonstrates that both disciplines are grounded in shared conceptual foundations. Mathematics was first introduced in French schools of architecture and later in the Bauhaus and similar schools. Mathematics had a significant impact on the French education system, serving as a model for other technical schools and becoming a defining element of the school's identity. For example, mathematics courses at École Polytechnique are considered a core subject in the curriculum and are a key criterion in the entrance exams since the school's establishment (Brechenmacher, 2019). The work Géométrie Descriptive (1795) by mathematician Gaspard Monge and the Précis des leçons d'architecture (1802–1805), prepared by the rationalist architectural theorist Jean-Nicolas-Louis Durand at the École Polytechnique in Paris, represent significant milestones in the historical development of the relationship between architecture and mathematics (Aydın, 2024) (Fig.3).

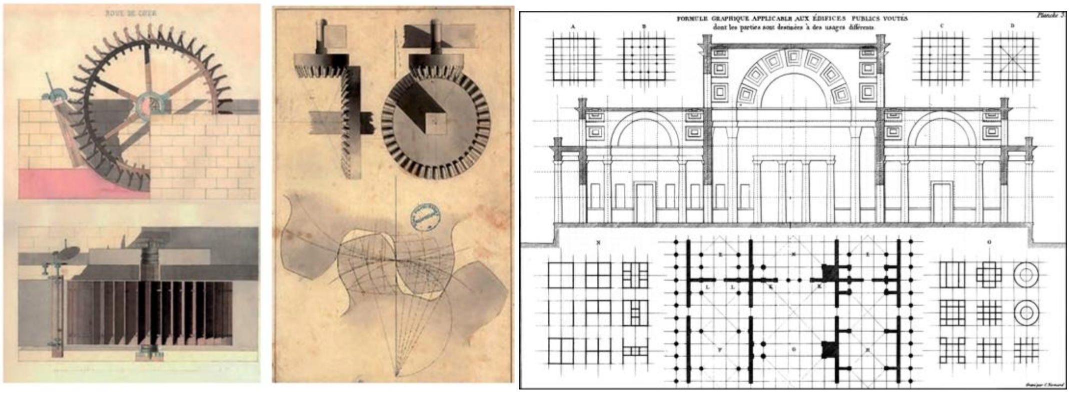

Figure 3. a Student-created illustrations of descriptive geometry applications in Ecole des Polytechnique (Brechenmacher, 2019) Figure 3.b Jean-Nicolas-Louis Durand's drawings (Goudeau, 2015).

Regarding the Bauhaus, handcraft workshops provided education in a core curriculum that included descriptive geometry, mathematics, physics, chemistry, as well as instruction in arts, sciences, and professional skills. Starting in 1928, Friedrich Köhn, Alcar Rudelt, Erich Schrader, Willi Saemann, and Friedrich Engemann taught mathematics and geometry-related courses part-time at the Bauhaus. The Fourth Industrial Revolution, which comes with developments in artificial intelligence, robotics, and similar fields, has increased the need for new and creative teaching methods, especially in the field of education. In order to prepare students for this rapid change process, it is important to develop mathematical skills. Thus, students' creativity, motivation, and problem-solving skills are supported (Bernardez & Alenton-Oracion, 2023). In this context, an article on teaching mathematics in design education discusses the content of a course that they conducted at the New Jersey Institute of Technology using analogue methods (Kappraff,1983). Kapraff states that they planned to collaborate on a second course in which the ideas generated in this course could be developed through computer applications. At the time of writing, much of the technology and software needed to analyse graph theory, tile the plane, design polyhedral, transform shapes through isometry and projection, experiment with symmetry, and make creative use of vectors, lines, and planes was already available. A particularly important point emphasized in the article is that such a course should first be taught without computer support, that is, with analogue methods. It is argued that students need to experience these fundamentals directly before they can fully grasp how computers can enrich their design experience (Kappraff,1983). Mathematical thinking functions as a tool in the processes of form generation and conceptualization in architecture, establishing a balance between abstract and material components, and creating a link between aesthetic and technological requirements. According to Wittmann (1998), the fundamental goal of mathematics education can only be achieved when research and development processes are directly linked to practice and when improvements in practice are integrated with the field's overall progress. With the advancement of digital technologies, the role of mathematics in architecture has become even more prominent, offering new possibilities, particularly in the design of free-form architecture. More recently, the emergence of artificial intelligence, machine learning and generative design systems has further transformed the relationship between mathematics and architectural education. These developments require students not only to use digital tools but also to understand the mathematical principles underlying algorithmic decision-making and data-driven design processes (Günaydın Donduran et al., 2024).

1.3 Mathematics Courses in Architectural Education

The pedagogical approaches that emerged in the historical period paved the way for architects to consciously or unconsciously bring the discipline of architecture closer to mathematical thinking. If we look at the status of mathematics courses today, the relationship between geometry and architecture is addressed not only in formal terms but also as a cultural and intellectual unity. In this context, mathematics is also considered a fundamental mode of thinking that nourishes architectural practice (Fawzy & Abdel Sabour, 2020). Compared to interior architecture education, mathematics courses are given more emphasis in architecture programs. For example, the mathematics course offered to third-year students at the Faculty of Architecture at METU covers a broad range (from basic geometry to fractals and biomimicry) and aims to foster a positive perception of mathematics as a design tool (Sorguç, 2005). The course emphasizes the integration of mathematical and algorithmic thinking into the design process, encouraging students to express ideas, evaluate options, and solve complex problems. It is stressed that mathematics does not limit creativity but instead supports problem-solving within design constraints. Additionally, students who take this course tend to adapt more successfully to digital and computational design courses, demonstrating higher levels of performance and engagement.

In Mexico, at Tecnológico de Monterrey University, a mathematics course designed for architecture students was restructured based on a Problem-Based Learning (PBL) approach. Instead of traditional mathematics instruction, the course adopted a design- and architecture-centred perspective. Its design drew on successful PBL experiences from engineering programs and addressed both national and international architectural education requirements. The content was organized around functions and modelling, derivatives and optimization, applications of integrals in architectural and structural design, vectors and physics-related concepts, and Euclidean, spherical, and fractal geometry. The course emphasized practical applications through architecture-specific scenarios such as parametric form generation, ergonomic product design, container optimization, and fractal architecture. Future improvements include broader faculty participation and the informed use of architecture-specific tools such as ArchiCAD. Overall, this model offers an innovative example of how to enhance architecture students' mathematical thinking within a professional context (Delgado-Cepeda, 2005).

Between 1995 and 2005, the mathematics education experience at the Faculty of Architecture of Roma Tre University aimed to go beyond the traditional curriculum by integrating contemporary mathematical thinking into architectural education. The program enabled students to engage with mathematical concepts not only theoretically but also through tools of visualization, modelling, and representation. In the first year, students developed fundamental mathematical literacy and problem-solving skills, while in the second year, abstract concepts of modern mathematics were contextualized through objects familiar to architecture students. In later years, students were encouraged to incorporate mathematical tools into the design process through individual projects and elective courses via digital & analogue methods. Assessment was structured through continuous monitoring, self-evaluation exams, and practical assignments. This experience demonstrated that mathematical content can be constructively and practically restructured within architectural education (Pagano & Tedeschini, 2005).

Another example is the pedagogical redesign of the mathematics course for first-year students at the Faculty of Architecture at Liège University in Belgium, conducted as part of the "Feedback First-Year Project." This initiative aimed to enhance students' learning experiences and involved implementing four main tools: the Online Prerequisite Test (PT), the True/False Quizzes & Midterm Test (IT), the Peer-Assessed Mock Exam, and the Online Graphical Course Program. The article highlights that this pedagogical redesign could serve as an inspiring effort for other first-year teachers and emphasizes the importance of formative feedback and "assessment for learning" theories in supporting student participation (Jancart et al., 2018). Also in Portugal, Consiglieri & Consiglieri (2003) proposed a one-year mathematics program for architecture students, emphasizing the importance of modern mathematical concepts like topology for analysing complex forms in contemporary architecture. According to the article's suggestions, the one-year program should include graph theory, geometric structures, and ratio theory in the first semester, and an introduction to real-valued functions (in 1, 2, and 3 dimensions), composition of functions, topology concepts, continuity, and differentiability in the second semester.

Recent pedagogical research has increasingly focused on computational and pattern-based approaches in design education. For instance, pattern-based geometry instruction has been shown to strengthen spatial reasoning and form-generation skills in interior architecture education, while simultaneously fostering connections between geometric thinking and contemporary design practices (Baksi Mazlum & Onay, 2026). Similarly, computational learning environments have been reported to support students' understanding of the relationship between mathematical structures and design decision-making. Additionally, Pedemonte's study examines differences in teaching mathematics at architecture schools across various European countries. The study highlights the relationship between architecture history, mathematics, and construction science, as well as the need to strengthen the interaction between computer science and architecture. In Belgium, ISAI (Instituts Supérieurs d'Architecture Intercommunaux) schools focus on basic mathematical subjects, while universities emphasize mathematics and computer science alongside engineering education. In France, mathematics education is less prominent, with more focus on descriptive geometry and topology. In Portugal, architecture education has shifted to specialized faculties, and entrance requires passing exams in mathematics. In Spain, mathematics education is similar to Italy's, with courses offered in the early years and more emphasis on computer science. In Switzerland, education is more technical, with mathematics and geometry courses playing an important role (Pedemonte, 2001). It is argued that mathematics not only holds historical significance for architecture and fine arts but also forms the foundation of modern design and technology, playing a critical role in adapting to future challenges (Venetis, 2020).

There are notable cross-national differences in how mathematics is approached in architectural education (Table 1). While some countries like Türkiye, Mexico, and Italy adopt a creative, design-oriented integration, others, such as France, Portugal, and Belgium, follow a more traditional path. Overall, mathematics is increasingly viewed not just as a technical discipline but as a tool that enriches architectural thinking.

Table 1. Summary table of mathematics courses in architectural education (Developed by the Authors).

Country	Summary of approach	Applied method / course content	Outcomes & highlights
Türkiye	Integrated & applied	Fractals, biomimicry, algorithms	Mathematics as a design tool; supports creativity
Mexico	PBL-based, architecture-specific	Functions, integrals, vectors, fractal geometry	Linking to real design problems
Italy	Modern mathematics & visualization	Basic literacy, modelling, digital/analogue tools	Theoretical knowledge is translated into design projects
Belgium	Fundamentally focused, simple approach	Basic mathematics topics	Building on basic skills
Portugal	Theoretical modern mathematics	Topology, ratio theory, functions, continuity	Mathematical foundation for understanding contemporary architecture
France	Traditional-geometric	Descriptive geometry, topology	Focus on visual expression and geometry
Spain	Technical & computer based	Mathematics, together with computer science	Linking digitalization and engineering
Switzerland	Technical & engineering based	Comprehensive mathematics & geometry	High technical competence, digital adaptation

There are notable cross-national differences in how mathematics is approached in architectural education. While some countries like Türkiye, Mexico, and Italy adopt a creative, design-oriented integration, others such as France, Portugal, and Belgium follow a more traditional path. Overall, mathematics is increasingly viewed not just as a technical discipline but as a tool that enriches architectural thinking.

2. Materials and Methods

This study uses a five-stage qualitative research design to examine the existence, scope and pedagogical positioning of "Design Mathematics" courses in interior architecture undergraduate programs in Türkiye. The main method is document analysis, and the analysis process is structured around a systematic coding and categorization framework, supported by descriptive quantitative mapping and visual modelling of course distributions (Fig. 4).

In the first stage, a comprehensive literature review was conducted to provide a conceptual and pedagogical framework for design mathematics in international architecture and design education. This review included the historical development of design mathematics and current curricular approaches and formed the theoretical basis for the analytical lenses used in the study.

In the second stage, interior architecture undergraduate programs in Türkiye were identified and their official curricula were systematically collected through institutional websites and digital information systems. In this context, based on the 2025 data of the Council of Higher Education (YÖK), the curricula of 90 universities in Türkiye offering active undergraduate programs in interior architecture or interior architecture and environmental design were systematically examined for the 2025 academic year using the document analysis method. The curricula of all identified programmes were transferred into a spreadsheet database and systematically reviewed. Course titles, descriptions, objectives, and learning outcomes were examined line by line. Courses were initially flagged when the term mathematics was explicitly mentioned in the course title, description, objectives, or learning outcomes. In addition, courses were included when

mathematical knowledge or concepts (e.g., geometry, calculus, algorithms, computation, optimisation, proportion, or mathematical modelling) were directly addressed, even if the term mathematics itself was not explicitly used.
In the third stage, course descriptions, objectives, learning outcomes, and teaching methods were obtained from official digital course catalogues and Bologna Process information systems. In line with the inclusion criteria determined through the literature review, the courses were re-evaluated and filtered according to their relevance to design mathematics. In this context, qualitative content analysis based on thematic coding was employed to determine the conceptual positioning of each course. The codes were developed using both literature-driven and data-driven approaches. Within this framework, three analytical lenses were constructed: curricular positioning of mathematics courses, the relationship between mathematics and design thinking, and operative and thematic roles. The detailed definitions of these codes are presented in the Results section. Qualitative content-document analysis guided by predefined analytical categories and quantitative coding that allows for comparison were employed (Creswell & Creswell, 2020, p. 188-196). In the fourth stage, a total of 40 courses were identified as directly related to design mathematics. These courses were subjected to qualitative content analysis and firstly positioned in line with the triangular conceptual framework. The contents of the courses were also evaluated in terms of their thematic and operational dimensions.

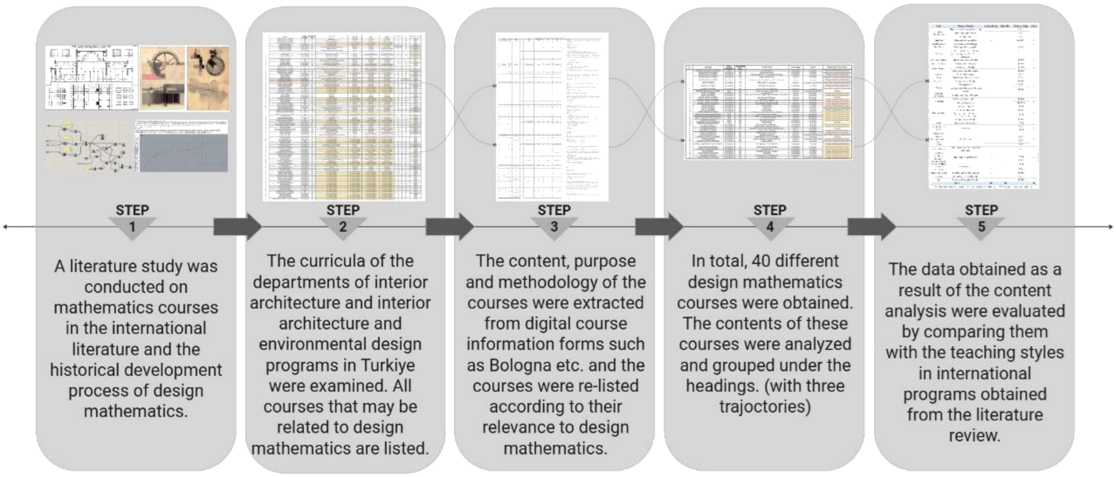

Figure 4. Methodology Diagram. (Developed by the Authors).

Thus, both the epistemological positioning of the courses and their production- and practice-oriented dimensions were analysed in an integrated manner. The categorisation process was conducted through an iterative coding approach to ensure analytical consistency across institutions. In the fifth and final stage, the findings from curricula in Türkiye were evaluated in comparison with international approaches identified in the first stage, in order to discuss the potential benefits of strengthening the role of mathematics-related courses in design education.

3. Results

The study examined the curricula of 90 undergraduate programs in interior architecture and interior architecture and environmental design departments at universities in Türkiye and the Turkish Republic of Northern Cyprus that are registered with the Turkish Higher Education System. For this purpose, the 4-year curriculum information and elective course lists on each university's website were analysed. Courses that directly mentioned mathematics in the course title or taught mathematics in their content were selected. The content of 112 different courses potentially related to design mathematics was examined in the information system of each department's internet archive. A total of 40 different design mathematics courses were identified when the content and purpose of the courses were examined. Thirty-two of these courses are offered at foundation universities and eight at state universities. Eight of these mathematics courses are offered at public universities that accept students with a Maths-Science score. Sixteen are offered at universities that accept students with a Turkish-Maths score, and the remainder are offered at foundation universities that accept students with a Maths-Science score. Based on this, it was determined that design mathematics courses are mostly included in Interior Architecture undergraduate programs that accept students with mathematics/science (MS) score.
Fifteen of these courses are in the Interior Architecture and Environmental Design department, while 25 are in the Interior Architecture department. A total of 20 "Design Mathematics" courses are compulsory, and 20 are elective. It is observed that these courses are more prevalent in foundation universities than in state universities, regardless of whether they are elective or compulsory. In programs where design mathematics courses are compulsory, they are all in the first year (Fig. 5). In addition, 18 of these courses are given in the first semester as soon as the students start their education, while 2 of them are given in the second semester. The classes that offer elective courses vary from those of the compulsory courses. The elective courses are primarily found in the 3rd year (6 courses), 2nd year (4 courses), 4th year (3 courses), and 1st year (2 courses). When looking at the semesters in which they are offered, it was observed that the compulsory courses are primarily taught in the 1st year, 1st semester (18 courses), with only 2 courses being offered in the 1st year, spring semester. It was also noted that most of the elective courses (10) are not confined to a specific semester and can be taken during any desired semester.

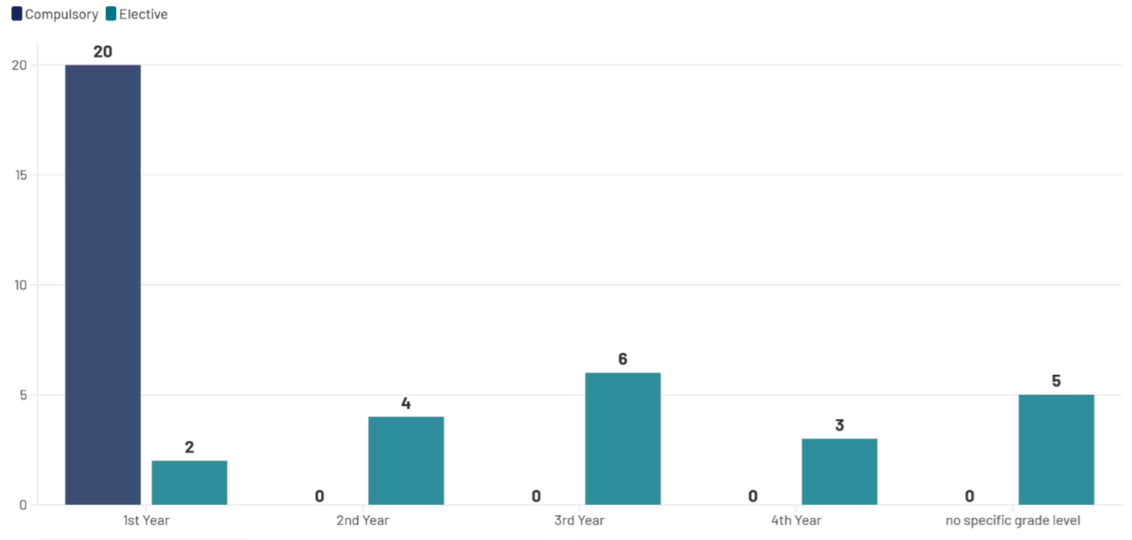

Figure 5. Quantitative graphs of design mathematics courses. (Developed by the Authors).

In literature, there are various classifications of mathematics courses in architecture and design programs. For example, "Mathematics for/in/at Architecture"; in another source, mathematics courses are classified under three headings as "General mathematical courses (GMC)", "Design-oriented mathematics (DOM)", "Production-oriented mathematics (POM)" (Sheibaniaghdam & Selçuk, 2022; Ostwald & Williams, 2015; Cikis, 2010). Ostwald & Williamd (2015) in their article prefer the term *"Mathematics in Design"* to show how mathematics is applied in the design process; *"Mathematics for Design"* to describe the mathematical knowledge required for designers; and *"Mathematics of Design"* to explain the role of mathematics in design in a broader framework. Cikis (2010) uses three different headings to classify mathematics courses. *General mathematical courses (GMC)* are defined as courses aimed at training professionals in basic and advanced mathematics; *production-oriented mathematics (POM)* are defined as courses that include geometry knowledge to rationalize architectural production processes; and *design-oriented mathematics (DOM)* are defined as courses related to architectural design processes (Cikis, 2010). On the other hand, Burry & Burry (2010) discuss the intersection of mathematics and architecture in their book "*Mathematical Surfaces, Chaos / Complexity / Emergence, Packing & Tiling, Optimization, Topology, Datascapes & Multi-dimensionality"* on sample project outputs. When the content, aims and objectives of the courses were analysed, it was found that they overlapped with the classification proposed by these three sources. In this study, the curricula are examined through three complementary analytical lenses. While the first lens focuses on the curricular positioning of mathematics courses, the second lens conceptualizes the relationship between mathematics and design thinking. The third lens reveals the operative and thematic roles of mathematics within design processes. The overlapping of these lenses allows for a multi-dimensional reading of mathematics education in interior architecture (Fig. 6).

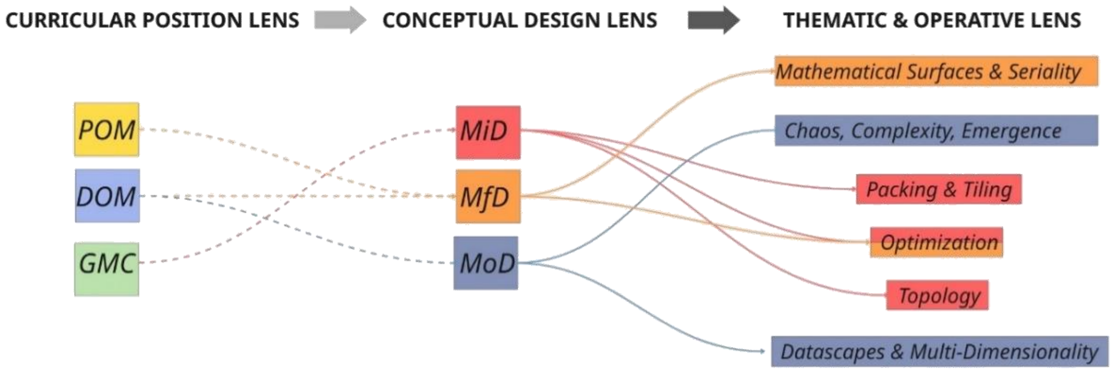

Figure 6. Distribution graph of design mathematics courses. (Developed by the Authors).

As a result of the content analysis, it is seen that the majority of the courses (16) are in GMC content, and matrix, limit, integral, and similar calculus courses are given. Of these courses, 11 are compulsory and 5 are elective. The number of DOM courses is 12 in total, 8 of which are elective. POM courses are associated with 7 courses, 3 compulsory and 4 electives. GMC courses are mainly offered in the first year (11), DOM courses are offered in the first year (5), second year (1), third year (3), fourth year (2); POM courses are offered in the first year (4) and fourth year (1). In addition, among the compulsory courses, 15 were identified as Mathematics for Design (MfD)-oriented, 11 as General Mathematics Courses (GMC), and 9 as focused on optimization. Among the elective courses, 6 were identified as Design-Oriented Mathematics (DOM), 8 as Mathematics in Design (MiD), and 8 as optimization and dataspace & multi-dimensionality–oriented courses.

Within the Curricular Position Lens, it is observed that production-oriented mathematics courses are the least frequently coded among compulsory courses. Within the Conceptual Design Lens, Mathematics of Design (MoD) courses represent

the least frequent category. Within the Thematic & Operative Lens, the least frequently coded themes are chaos, complexity, topology, packing & tiling, and datascapes.
When elective courses are examined, a relatively balanced distribution is observed across the Curricular Position Lens. However, within the Conceptual Design Lens, Mathematics of Design (MoD) again appears as the least frequently coded category. Within the Thematic & Operative Lens, topology and packing & tiling are the least frequently represented themes (Fig. 7).

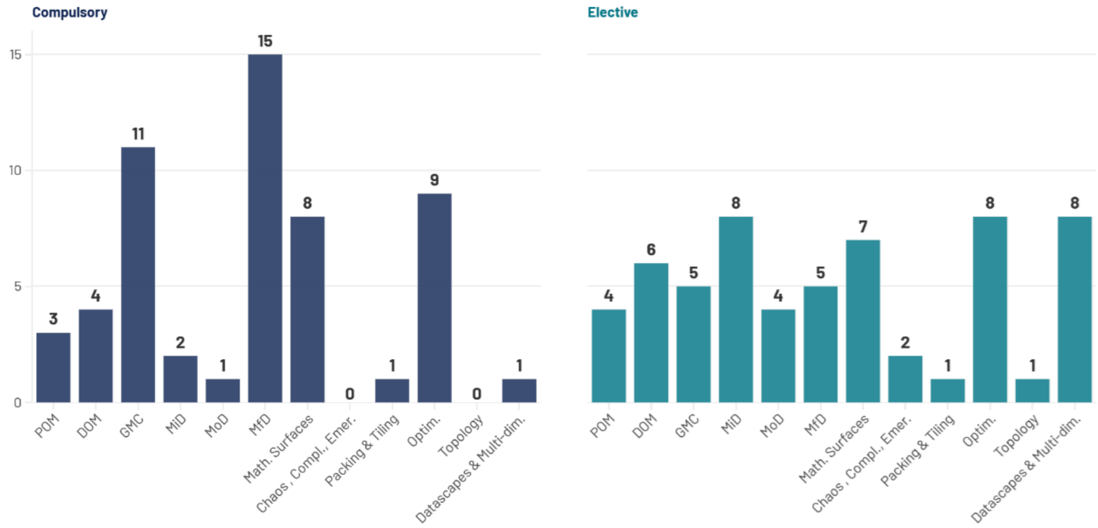

Figure 7. Distribution graph of design mathematics courses according to content & type of mathematics courses (b). (Developed by the Authors).

When the distribution of courses is examined in greater detail, a more differentiated institutional pattern becomes visible. In total, 19 courses are offered in the first semester regardless of their content, while 9 courses are not bound to a specific semester and can be taken flexibly across the curriculum. A clear institutional pattern emerges in terms of course ownership: all Design-Oriented Mathematics (DOM) courses are located in foundation universities, while General Mathematical Courses (GMC) are distributed across both foundation (n = 11) and state universities (n = 5). Notably, all Production-Oriented Mathematics (POM) courses are offered exclusively in foundation universities. This distribution is also related to infrastructural capacity, particularly laboratory and maker-space facilities, in terms of the inclusion of production-oriented mathematical content in curricula. When the overall distribution of course types is examined, GMC courses constitute the largest proportion of the curriculum (40%), followed by DOM courses (30%), and POM courses (17.5%). This indicates a dominant emphasis on foundational mathematical instruction, with comparatively limited representation of design- and production-integrated mathematical approaches.
The comparison between programmes admitting students with Mathematics-Science (MS) and Turkish-Mathematics (TM) scores reveals a systematic structural differentiation in the curricular positioning of design mathematics. MS-based programmes demonstrate a higher concentration of mathematics-related courses, particularly GMC-type courses, which are predominantly positioned in the first year as foundational knowledge. In contrast, TM-based programmes exhibit a comparatively reduced number of explicit mathematics courses, with a stronger tendency to embed mathematical reasoning within design-oriented (DOM) and production-oriented (POM) frameworks. This suggests that in MS-based programmes mathematics is primarily conceptualised as a preparatory cognitive foundation, whereas in TM-based programmes it is more frequently integrated into design and computational contexts. Overall, the findings indicate that admission type is associated not only with student intake profiles but also with the epistemological framing and curricular positioning of mathematics within interior architecture education. The distribution of courses in terms of elective and compulsory status, as well as their classification under the Curricular Position Lens (GMC, DOM, POM) and the Conceptual Design Lens (MiD, MfD, MoD), is presented in Table 2.
This classification enables a multi-layered examination of how mathematics-related courses are structured within interior architecture curricula, allowing for a comparative reading across institutional types and pedagogical orientations. The thematic and operative characteristics of the courses are further interpreted through predefined analytical categories derived from the literature and empirical coding process, including Mathematical Surfaces, Chaos/Complexity/Emergence, Packing & Tiling, Optimization, Topology, and Datascapes & Multi-dimensionality. These categories were used to systematically map the learning outcomes and content orientations of each course, ensuring consistency across different programme structures. Courses for which complete documentation (such as course descriptions, learning outcomes, or syllabi) was unavailable were excluded from thematic classification to maintain analytical reliability and comparability across the dataset.

Table 2 : Universities with mathematics courses in the curriculum.

Uni.	Course Name	Com.	Elec.	Course Types			Total
Dumlupınar	History of Mathematical Concepts	-	1	GMC[a]	MoD[f]	Chaos & Comp. & Emergence	3
	Mathematics and Nature	-	1	GMC[a]	MoD[f]	-	
	Mathematica	-	1	GMC[a]	MfD[e]	Datascapes & multi-dim.	
Çankaya	Geometry for Architects	1	-	DOM[b]	MfD[e]	Math. Surfaces & Seriality	1
Istanbul Kent	Algorithm Based Design	-	1	-	-	-	1
Bilkent	Thinking Mathematically I	1	-	GMC[a]	MfD[e]	-	1
Özyeğin	Mathematics for Social Sciences	1	-	GMC[a]	MfD[e]	Optimization	1
	Algorithm Supported Architectural Geometry	-	1	-	-	-	1
Istanbul Gelişim	Algorithmic Design Studies	-	1	DOM[b]	MiD[d]	Datascapes & multi-dim. + Optim.	1
Izmir Economy	Architectural Geometry	-	1	DOM[b]	MiD[d]	Math. Surfaces & Seriality + Optim.	1
Rumeli	Geometry in Design	-	1	DOM[b]	MoD[f]	Packing & Tiling + Topology + Math. Surfaces	2
	Architecture and Mathematics	-	1	DOM[b]	MoD[f]	-	
Atatürk	Basic Mathematics	1	-	GMC[a]	MfD[e]	Optim.	1
Yaşar	Calculation in Social Sciences	-	1	GMC[a]	MfD[e]	Datascapes & multi-dim.	1
Bahçeşehir	Computational Design	-	1	DOM[b]	MiD[d]	Datascapes & multi-dim. + Math. Surfaces & Seriality	1
Doğuş	Mathematics I	-	1	GMC[a]	MfD[e]	Optimization	2
	Computational Methods in Practice Design	-	1	DOM[b]	MiD[d]	Optim. + Datascapes & multi-dim.	
Eskişehir Tech.	Design and Space Geometry	-	1	-	-	-	1
Kadir Has	Mathematics for Architects	-	1	DOM[b]	MfD[e]	Math. Surfaces & Seriality + Optim.	2
	Design Calculation	-	1	POM[c]	MiD[d]	Optim. + Math. Surf. & Seriality + Datascapes & multi-dim.	
Bilgi	Design Geometry	1	-	POM[c]	MiD[d]	Packing & Tiling & Math. Surfaces	4
	Design Mathematics	-	1	DOM[b]	MiD[d]	Datascapes & multi-dim.	
	Computational Building Information Modeling	-	1	POM	MiD[d]	Optim. + Datascapes & multi-dim.	
	Computational Design	1	-	DOM[b]	MiD[d]	Math. Surfaces & Optim.	
MEF	Fabricated Atmospheres	-	1	POM[c]	MiD[d]	Math. Surfaces & Optim.	1
Belek Toros	Geometry	1	-	GMC[a]	MfD[e]	Math. Surfaces & Seriality	2
		1	-	POM[c]	MfD[e]	Math. Surfaces & Seriality	
Iskenderun Tech. Istanbul Ticaret Toros Trakya	Mathematics	1	-	-	-	-	4
		1	-	GMC[a]	MfD[e]	Optim.	
		1	-	GMC[a]	MfD[e]	-	
		1	-	GMC[a]	MfD[e]	Optim.	
Doğu Akdeniz	Mathematics and Geometry for Designers	1	-	GMC[a]	MfD[e]	-	1
Istanbul Medipol/ Maltepe / Ostim Teknik	Mathematics for Designers	1	-	-	-	-	3
		1	-	POM[c]	MfD[e]	Math. Surfaces & Optim.	
		1	-	GMC[a]	MfD[e]	Math. Surfaces	
Ankara Medipol/ Istanbul Tech.	Mathematics I	-	1	POM[c]	MfD[e]	Math. Surf.	2
		1	-	GMC[a]	MfD[e]	Optim.	
Sab. Zaim	Mathematics of Architecture	1	-	DOM[b]	MfD[e]	Optim. + Math. Surf.	1
Altınbaş	Mathematics of Architecture I	1	-	GMC[a]	MfD[e]	Optim.	1
Işık	Numbers, Formulas, People I	1	-	DOM[b]	MoD[f]	Chaos & Complexity & Emergence + Datascapes & Multi-Dimensionality	1
	Total	**20**	**20**				**40**

[a] General Mathematical Courses [b] Design-oriented Mathematics [c] Production-oriented Mathematics [d] Mathematics in Design [e] Mathematics for Design [f] Mathematics of Design

The Sankey diagram was employed to visualize the relationships between course types, the positioning of mathematics within design, and their thematic distributions. To enhance readability, these relationships were presented through two consecutive Sankey diagrams: the first mapping course types to the conceptual positioning of mathematics in design, and the second illustrating thematic distributions. This stepwise representation enables a clearer interpretation of structural positioning prior to examining thematic concentrations. First, the relationship between the Curricular Position Lens (GMC / DOM / POM) and the Conceptual Lens categories was analysed. The findings indicate that General Mathematical Courses (GMC), which constitute a significant portion of the curriculum, predominantly correspond to the "Mathematics for Design" (MfD) framework. Moreover, all three course types appear to be largely taught with an MfD orientation. The relatively limited presence of "Mathematics of Design" (MoD) courses within the curriculum is also noteworthy (Fig. 8).

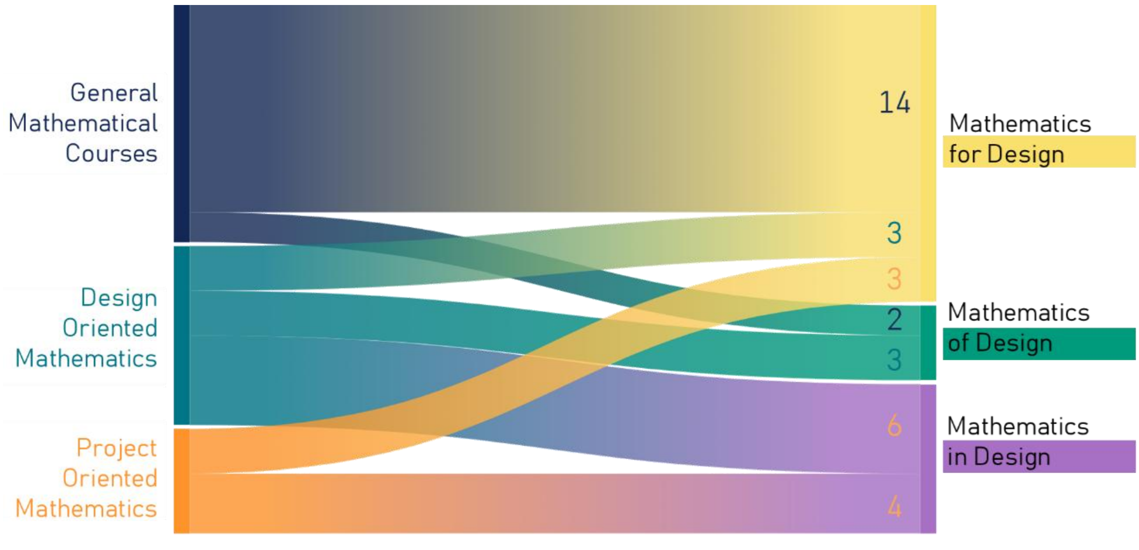

Figure 8. Sankey diagram of mathematics course types according to their positioning in design education. (Developed by the Authors).

The second Sankey diagram demonstrates that different positional framings of mathematics within design education are strongly associated with specific thematic areas (Fig 9). The predominance of optimization themes within the "MfD" category indicates that this approach is largely framed in an instrumental and performance-oriented manner. In contrast, the "MiD" position shows a stronger connection with digital production themes such as data structures and parametric surfaces. The "MoD" category, although represented by fewer courses, appears to be linked to more theoretically grounded themes. Overall, this distribution suggests that mathematics in architectural curricula is predominantly positioned as a technical and operational tool, while its theoretical dimension remains comparatively limited.

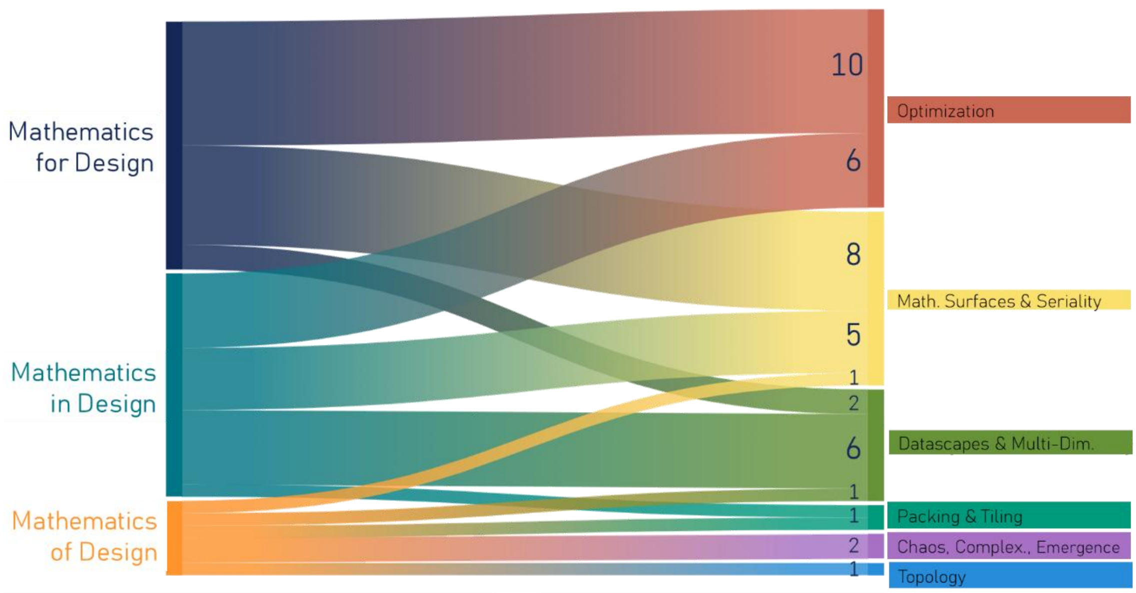

Figure 9. Sankey diagram of conceptual lens according to its positioning within thematic & operative lens. (Developed by the Authors).

The overall analysis indicates that mathematics courses within architectural curricula are predominantly positioned within the framework of "MfD". General mathematics courses are largely structured as supportive tools for the design process, emphasizing calculation and optimization. In contrast, DOM and POM courses tend to position mathematics as "MiD," integrating it more directly with parametric modelling, algorithmic processes, and digital fabrication techniques. Courses categorized as "MoD" are fewer in number; however, they offer greater theoretical and conceptual depth in terms of content. The thematic distribution further reveals that optimization, multidimensional data structures (datascapes), and mathematical surfaces emerge as the most dominant areas.

4. Discussion

The findings of this study confirm the instrumentalization trend emphasized in the existing literature on the position of mathematics in architectural education. Previous studies indicate that mathematics is mostly addressed in the architectural curriculum within the framework of technical competence, computational skills and performance analysis. This study, on the other hand, concretizes this trend through a quantitative distribution model and reveals that mathematics is predominantly positioned within the scope of the "Mathematics for Design" approach. In addition, the study proposes a methodological framework for the field by systematically categorizing the "for-in-of" distinction, which is usually discussed at the conceptual level in the literature, through curriculum analysis. The results show that the "Mathematics of Design" approach in particular is underrepresented in the curriculum. This finding may also be interpreted in relation to recent developments in computational design pedagogy. While contemporary design education increasingly emphasises algorithmic reasoning, parametric thinking and data-driven decision making, these competencies rely on a deeper understanding of mathematical structures rather than solely technical software skills. Recent studies suggest that computational design education becomes more effective when mathematics is positioned as a mode of reasoning embedded within design processes rather than as an external technical requirement (Vazquez, 2023). From this perspective, the limited representation of Mathematics of Design identified in Turkish interior architecture curricula may indicate a broader gap between traditional mathematics instruction and emerging computational design practices.

This suggests that the mathematical foundations of design (such as topology, proportion, complexity or formal logic) are less theorized. This is where the study identifies an important gap: it is not just about the existence of a mathematics course, but also about the position of mathematics within the epistemology of design. This perspective raises the question of whether mathematics is an instrumental technical field or a constitutive component of design thinking in architectural education. First, within the Curricular Position Lens, GMC emerged as the predominant course type. In the second step, the analysis of the Conceptual Design Lens revealed that MfD constituted the dominant positioning. Finally, when examining the Thematic & Operative Lens, which relates to the intended learning outcomes and thematic orientations of the courses, optimization was identified as the most prevalent focus (Fig. 10).

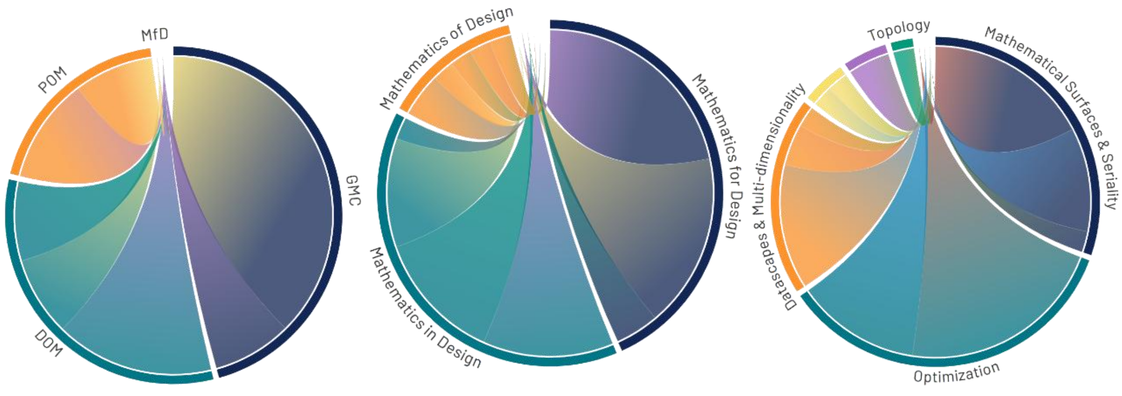

Figure 10. Sankey diagrams of mathematics courses according to its positioning within design education. (Developed by the Authors).

This tripartite analytical structure is particularly significant because it operationalizes the "mathematics for–in–of design" distinction, which is often discussed at a conceptual level in the literature, into a systematic and comparable framework for curriculum analysis. By translating these conceptual categories into measurable curricular lenses, the study enables not only the identification of course distributions but also a deeper examination of how mathematics is epistemologically positioned within design education.

This dominant instrumental positioning of mathematics within interior architecture curricula can be interpreted in relation to structural and institutional characteristics of higher education in Türkiye. First, the centralized university entrance examination system (YKS) tends to prioritize early-stage mathematical competence primarily as a selection mechanism rather than as a design-integrated cognitive tool, which may reinforce the perception of mathematics as a preparatory rather than constitutive component of design education. Second, the studio-centred pedagogical structure of interior architecture programs allocates a disproportionate share of curricular time to design studios, thereby positioning theoretical and analytical courses, including mathematics, as supportive rather than integrative elements. Third, accreditation requirements and standardized curriculum frameworks across universities tend to emphasise fundamental mathematical competencies in early semesters, which may explain the observed concentration of GMC-type courses at the beginning of the programme. Within this context, the limited presence of Mathematics of Design (MoD) courses reflects not only pedagogical preferences but also structural constraints in curriculum design and workload distribution.

The contribution of the research lies in making visible the role of mathematics in architectural education through a multi-layered model by categorizing curricular content thematically and spatially. This model can be used in future comparative analyses of architecture programs in different countries, in studies examining the evolution of digital design-oriented programs, and in tracking pedagogical transformations. It also opens new avenues of research to measure the level of integration between the design studio and mathematics courses.

However, the study has some limitations. The analysis is based solely on the descriptions in the course catalogues; the actual delivery or pedagogical depth of the courses was not assessed. Moreover, the thematic categorization was based on certain conceptual frameworks, and different researchers may propose alternative categorizations. It is suggested that future research should examine the level of implementation of course content through studio outputs, evaluate student experiences, and analyse the pedagogical position of mathematics in more depth through qualitative interviews with faculty members. In addition, it is thought that curriculum models will be developed to strengthen the "Mathematics of Design" approach. It is thought that the skills of understanding algorithmic thinking, bridging data and design, collaborating with AI, and producing innovative and computable designs, which are the necessities of the age, will be provided by expanding the scope of mathematics of design courses.

Based on the knowledge that AI is built on mathematical foundations such as statistics, linear algebra, geometry and calculus, it is obvious that without understanding these foundations, a designer will use AI tools limited to "off-the-shelf" solutions. Mathematical literacy can increase AI's capacity to be used as a tool and its partnership in the creative process by providing an understanding of how algorithms work and what kind of data and how they produce results. At the same time, a designer will need statistical literacy to be able to interpret and transform data when designing with data. Being able to transform rational data into creative design decisions will be possible with mathematical thinking. Contemporary approaches such as parametric design, algorithmic form generation, structural optimization are directly related to mathematical models. Therefore, it is thought that without knowing mathematics, such innovative methods can only be applied superficially.

There is no reference to the use of artificial intelligence in any of the course information sheets. While GMC provides the basic cognitive infrastructure for an AI-integrated interior architecture education, DOM supports algorithmic thinking and POM supports AI-supported production processes. Although each course is important for AI integration, it is recommended to give more weight to DOM and POM courses. The current curriculum structure in Türkiye includes a limited number of design mathematics courses compared to international programs. However, in programs where basic mathematics education is provided at an early stage, the integration of design and production-oriented mathematics courses has the potential to strengthen students' mastery of AI-based design tools. As a result, this study contributes to a broader academic debate arguing that mathematics in architectural education should be treated not only as a computational tool but also as an epistemological construct that shapes design thinking.

5. Conclusions

This study shows that the role of mathematics in architectural education should be evaluated not only in terms of its presence in the curriculum, but also in relation to its position in the design process. To this end, three different trajectories were constructed and courses analysed based on their content, objectives and learning outcomes. The findings suggest that mathematics is primarily presented as a tool that supports design, whereas its role as a constitutive component of design thinking is addressed more limitedly. This situation has significant implications, particularly in the contemporary context of the increasing widespread use of artificial intelligence and computational design tools.

The study's theoretical contribution lies in its proposal of a conceptual model for curriculum analysis, which frames mathematics within a tripartite structure. "Mathematics for Design", "Mathematics in Design", and "Mathematics of Design". This model provides an analytical framework that can be applied in different contexts to evaluate the role of mathematics in architectural education. Consequently, the focus shifts from the mere existence of mathematics courses to their role within design pedagogy. The findings also show that mathematics in architectural education is mostly taught within an instrumental and performance-oriented framework. The discipline's engagement with the ontological or formal foundations of design remains relatively limited. This suggests that, alongside the development of contemporary digital design practices, mathematics has become increasingly integrated with production and optimisation processes, while its conceptual and critical dimensions are underrepresented in the curriculum. Adopting a stronger "Mathematics of Design" approach could enrich design thinking, helping students to understand form generation as a mode of mathematical reasoning rather than merely a technical process. In this respect, mathematics in architectural education could be reconsidered as an epistemological framework that structures the logic of design, as well as a computational tool.

From the perspective of professional practice, the effective use of digital and AI-based tools extends beyond technical software proficiency. Understanding the mathematical logic underlying these tools enables designers to move beyond being passive users and to become conscious decision-makers capable of directing the process. Therefore, mathematical thinking should be considered a fundamental component of contemporary design practice. In terms of educational policy, mathematics courses should be strengthened not only with computational and technical competencies, but also with theoretical and conceptual content that nurtures design thinking. In particular, further development of the "Mathematics of Design" approach may contribute to establishing a stronger foundation for interdisciplinary and computational thinking skills in architectural education.

This study, by highlighting the epistemological and pedagogical positioning of mathematics, provides a contribution to literature beyond mere course content analysis. Future research should empirically examine the interaction between mathematics courses and design studio outputs to evaluate their impact on student learning. Moreover, the interdisciplinary potential of mathematics connecting architecture with data science, computer science, and engineering should be further explored. It is also important to ensure that strengthening mathematical thinking does not overshadow the intuitive and experiential dimensions of design.

In conclusion, this study suggests that mathematics should be reconsidered in architectural education, moving beyond its status as a mere technical requirement to become a fundamental element of the intellectual infrastructure of contemporary design. Mathematics should be positioned not only as a tool but as a core thinking framework that actively shapes design reasoning and creative decision-making.

Acknowledgements
This research was carried out within the scope of Mimar Sinan Fine Arts University Department of Interior Architecture Doctorate Program.

Funding
This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Conflicts of Interest
The authors report no conflicts of interest.

Data Availability Statement
All data generated or analysed during this study are included in this published article and its supplementary files.

Institutional Review Board Statement
The research involved publicly available datasets and thus did not require ethical approval.

CRediT Author Statement
Conceptualization: B.C.A, N.N.G; Data curation: N.N.G; Formal analysis: N.N.G; Investigation: N.N.G; Methodology: B.C.A, N.N.G; Project administration: B.C.A; Resources: N.N.G; Supervision: B.C.A; Visualization: N.N.G; Writing – original draft: B.C.A, N.N.G; Writing – review & editing : B.C.A, N.N.G All authors have read and approved the final manuscript.

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