Year 2025
Vol. 1, no. 1, 2025, pp. 1-13

A Systematic Literature Review on the Digitalization of Ethnomathematics in 101 Tower Taiwan

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Received: 20 May 2025| Revised: 25 June 2025| Accepted: 26 June 2025 | Published Online: 30 June 2025

Abstract

This study presents a systematic literature review exploring the integration of ethnomathematics in the context of the iconic Taipei 101 Tower through digitalization. The research aims to identify how mathematical concepts embedded in the cultural, architectural, and symbolic elements of the 101 Tower can be utilized in educational settings, particularly within the framework of digital learning tools. A total of 25 peer-reviewed articles published between 2013 and 2024 were selected using PRISMA methodology, focusing on keywords such as "ethnomathematics," "digitalization," "architecture," and "Taipei 101." The analysis reveals that the structure of the 101 Tower embodies rich mathematical patterns, including fractals, symmetry, proportions, and the Fibonacci sequence, all of which reflect Taiwanese culture and traditional beliefs. Furthermore, digital technologies—such as augmented reality (AR), virtual tours, and interactive apps—have enhanced students' engagement and understanding of these concepts. The study concludes that the digitalization of ethnomathematical elements of the 101 Tower has strong potential to foster culturally relevant mathematics education and promote global appreciation of local knowledge systems. This review contributes to the growing field of ethnomathematics by highlighting the relevance of cultural artifacts in mathematical education and interdisciplinary studies.

Keywords: *Digitalization, Ethnomathematics, Systematic Literature Review, Taipei 101 Tower.*

Cite: Suyono, A., & Lisnani. (2025). A Systematic Literature Review on the Digitalization of Ethnomathematics in 101 Tower Taiwan. *Journal of Emerging Technologies in Ethnomathematics, 1*(1), 1-13.

INTRODUCTION

Ethnomathematics is a field of study that investigates the relationship between mathematics and culture, recognizing mathematical practices embedded in the daily lives, traditions, architecture, and artifacts of various cultural groups (D'Ambrosio, 2007; Rosa & Orey, 2011; Rosa & Orey, 2016; D'Ambrosio, 2018; Ergene et al, 2020; Fauzi et al, 2020). It emphasizes how mathematical ideas are expressed, understood, and utilized within various cultural contexts (Maharani, 2024). The Taipei 101 Tower, once the tallest building in the world, is not only a marvel of engineering but also a repository of cultural symbolism deeply rooted in Taiwanese and Chinese traditions. This paper conducts a systematic literature review to uncover and analyze the ethnomathematical elements inherent in the structure of Taipei 101 (Nosek, 2019).

This perspective challenges the notion of mathematics as a purely universal and culture-free discipline by revealing how different communities conceptualize, use, and communicate mathematical ideas in contextually meaningful ways (Prahmana & D'Ambrosio, 2020; Pradana et al, 2022; Muhakimah & Arfinanti, 2023; Padang & Lubis, 2023). In the realm of architectural heritage, ethnomathematics has provided insightful analyses of how structures embody mathematical concepts such as symmetry, proportion, geometry, and measurement systems (Ascher, 1991; Barton, 2009; Radiusman et al, 2021). One iconic example of modern architecture rich in mathematical and cultural significance is the Taipei 101 Tower in Taiwan. Once the tallest building in the world, Taipei 101 exemplifies a fusion of modern engineering with traditional Chinese symbolism. Its design incorporates elements such as the bagua, Fibonacci sequence, number 8 symbolism, and scaling patterns reflective of fractal geometry and modular arithmetic (Lin & Lin, 2017). Despite its global recognition, comprehensive academic studies are scarce to investigate mathematical and cultural symbolism embedded in Taipei 101 through the lens of ethnomathematics. Most existing discussions focus on structural engineering or cultural symbolism in isolation, rather than integrating both perspectives using a systematic and scholarly framework.

Therefore, this study aims to conduct a systematic literature review (SLR) to synthesize existing research related to the ethnomathematical dimensions of Taipei 101. The review seeks to answer the following research question: *How has existing literature described and analyzed the mathematical and cultural aspects of Taipei 101 within the context of ethnomathematics?* By doing so, this paper contributes to the growing body of work that highlights how monumental architecture can serve as a medium for mathematical thinking contextualized within local culture and identity (Lisnani et al, 2023; Rosa & Orey, 2011).

Although there has been research on the structural engineering and cultural symbolism of Taipei 101, the integration of these two perspectives from an ethnomathematical viewpoint remains limited. Prior studies have primarily addressed either architectural aesthetics or engineering techniques without delving into how mathematical concepts are culturally embedded and represented within the structure. Furthermore, few works have conducted a systematic review

to consolidate what is currently known and unknown about Taipei 101 in the field of ethnomathematics.

Given this gap, the present study is guided by the following research problem: "How has existing literature described and analyzed the mathematical and cultural aspects of Taipei 101 within the framework of ethnomathematics? The main purpose of this study is to conduct a systematic literature review (SLR) to explore, categorize, and synthesize existing research related to the ethnomathematical elements of Taipei 101. Through this analysis, the study aims to identify patterns, themes, theoretical approaches, and research opportunities for future exploration. This research contributes not only to the understanding of ethnomathematics in architectural contexts but also provides a foundation for educational and cultural discourse surrounding mathematics in real-world structures.

METHOD

A systematic literature review was employed to gather and analyze relevant literature from databases such as JSTOR, Scopus, Google Scholar, and ScienceDirect. Keywords used included "ethnomathematics," "Taipei 101," "Taiwan architecture," "mathematics in culture," and "Chinese symbolism in buildings." Inclusion criteria involved peer-reviewed articles, books, and conference papers published from 2013 to 2024. The timeframe 2013-2024 was selected to ensure the inclusion of contemporary research that reflects modern developments in both ethnomathematics and architectural analysis.

Thematic analysis was conducted to identify recurring patterns and concepts related to mathematical and cultural elements in Taipei 101. This study employed a Systematic Literature Review (SLR) approach to identify, evaluate, and synthesize scholarly literature relevant to ethnomathematics in the context of architecture and culture in Taiwan, particularly the Taipei 101 Tower. This approach aims to provide a comprehensive and structured mapping of existing knowledge (Kitchenham & Charters, 2007).

1. Research Design

The research design followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) model, which involves four main stages: identification, screening, eligibility, and inclusion (Creswell, 2014; Moher et al., 2009). This procedure was selected to ensure transparency, replicability, and validity throughout the literature selection process.

2. Research Questions

To guide the SLR process, the PICo (Population, Interest, Context) framework was used (Joanna Briggs Institute, 2017): 1) Population (P): Studies on ethnomathematics; 2) Interest (I): Mathematical representations in cultural, architectural, and symbolic elements of Taipei 101; 3) Context (Co): Taiwan, particularly the Taipei 101 Tower and East Asian cultural heritage. Main

Research Question: “How are mathematical representations and cultural integration expressed in the architecture and symbolism of the Taipei 101 Tower in Taiwan?”

3. Literature Search Strategy

A systematic search was conducted across the following academic databases: Scopus, Web of Science, ScienceDirect, Google Scholar, DOAJ, and Garuda (for relevant local literature). Keywords and Boolean Operators: ("Ethnomathematics" OR "Cultural Mathematics") AND ("Taipei 101" OR "Taiwan Architecture") AND ("Symbolism" OR "Geometry" OR "Cultural Meaning")

Search limitations: 1) Publication years: 2013–2024; 2) Document type: Peer-reviewed journal articles, academic proceedings, and scholarly books; 3) Languages: English and Mandarin (translated into English)

4. Inclusion and Exclusion Criteria

Inclusion Criteria consist of: 1) articles addressing mathematical elements within East Asian culture or iconic architectural designs; 2) studies that explore symbolic or philosophical interpretations of geometric structures (Bonner, 2017); 3) publications within the 2013–2024 timeframe. Exclusion Criteria: 1) non-peer-reviewed articles; 2) studies focusing only on technical aspects of buildings without cultural or mathematical context; 3) duplicates or inaccessible full-text articles.

5. Selection Procedure and Data Synthesis

The selection procedure followed the PRISMA flow diagram:1) identification: A total of 178 documents were retrieved from all databases; 2) screening: Removal of duplicates and irrelevant titles (remaining: 94); 3) eligibility: Abstract and full-text assessments (remaining: 38); 4) inclusion: After eligibility review, 15 articles were included for final analysis. The data were analyzed using thematic analysis to identify patterns of ethnomathematical representation based on the following aspects: 1) geometrical structure (spiral patterns, feng shui principles, symbolic numbers); 2) philosophical-cultural concepts (Chinese beliefs, numerology of 8, feng shui influence); 3) historical and cultural context of construction and architectural symbolism. Each selected article was coded and categorized using Zotero (reference management) and NVivo (thematic coding software).

In this systematic literature review, NVivo was utilized as a qualitative data analysis tool to support the thematic coding and synthesis of relevant literature. A total of 25 peer-reviewed articles were imported into NVivo, allowing for an in-depth and structured analysis of the textual data. The software facilitated the identification, organization, and visualization of emergent themes related to the integration of ethnomathematics, Taipei 101 Tower, and digital technologies. Steps of Analysis using Nvivo described in Figure 1.

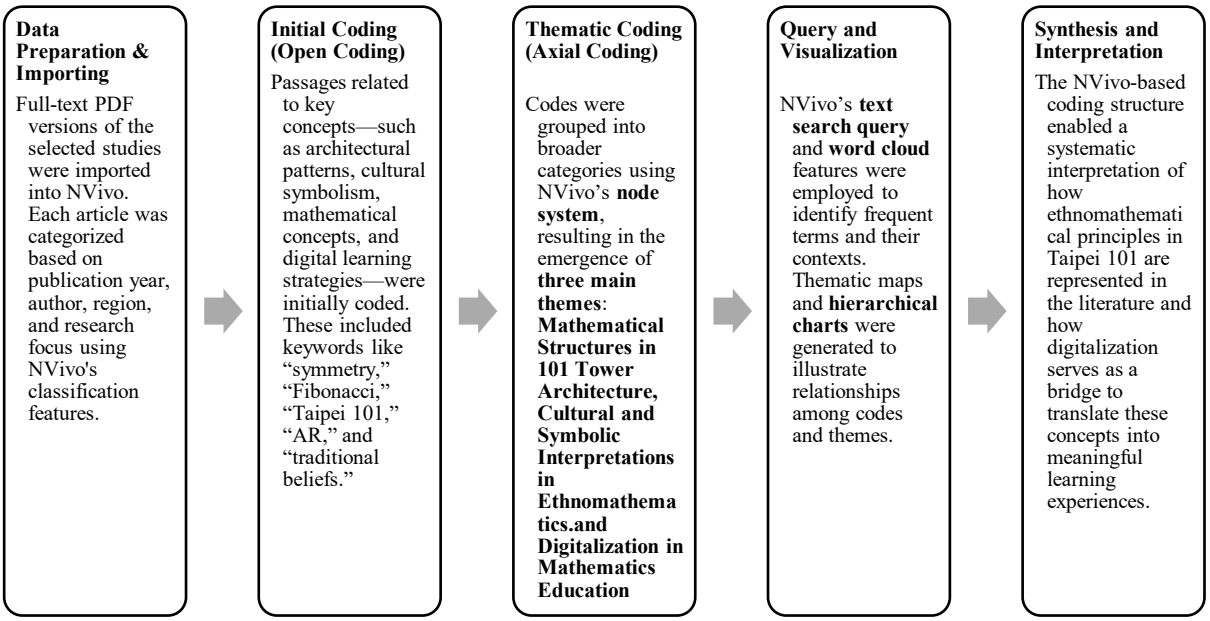

Figure 1. Steps of Analysis using Nvivo

6. Validity and Replicability

To enhance internal validity, an investigator triangulation strategy was implemented. Two independent researchers assessed the relevance of each article using a predefined evaluation form. Disagreements were discussed and resolved through consensus.

RESULT AND DISCUSSION

Result

1. Numerology and Symbolism

The number 8 is considered auspicious in Chinese culture, symbolizing prosperity and success. Taipei 101 consists of 8 segments of 8 floors each, reflecting this cultural value. The total number of 101 floors represents going beyond perfection (100), symbolizing continual progress.

2. Geometric Patterns and Proportions

The structure features repeating geometric motifs such as squares, circles, and octagons, which have symbolic and mathematical significance. The tower's design draws inspiration from a bamboo stalk, representing growth, flexibility, and resilience. Proportional analysis reveals adherence to the golden ratio in some architectural components, enhancing aesthetic harmony.

3. Feng Shui and Spatial Orientation

Feng shui principles guide the spatial layout and orientation of Taipei 101. The tower's entrance faces a favorable direction, and its design minimizes negative energy (sha chi). Mathematical modeling of wind resistance and seismic activity also integrates traditional knowledge with modern engineering.

4. Cultural Symbolism and Numerical Significance

Taipei 101's architecture is deeply rooted in Chinese cultural symbolism, particularly through its numerical design. The building comprises 101 floors, a number symbolizing the renewal of time and progression beyond perfection, as 100 is traditionally viewed as a symbol of completeness in Chinese culture. The structure is segmented into eight sections, each consisting of eight floors. The number eight is considered auspicious in Chinese numerology, representing prosperity and good fortune. This deliberate numerical structuring exemplifies the integration of cultural beliefs into architectural design, aligning with the principles of ethnomathematics, which explore the relationship between mathematics and culture.

5. Architectural Design Reflecting Cultural Artifacts

The building's design draws inspiration from traditional Chinese artifacts. Its tiered structure resembles a pagoda, a form historically associated with religious and cultural significance. Additionally, the building's silhouette is reminiscent of a bamboo stalk, symbolizing resilience and growth. These design choices reflect a conscious effort to embed cultural identity within the mathematical and structural framework of the skyscraper.

6. Incorporation of Traditional Symbols

Taipei 101 integrates traditional Chinese symbols into its design, such as the ruyi, a talisman symbolizing power and good fortune. These motifs are not merely decorative but are strategically placed to enhance the building's cultural resonance. Including such symbols demonstrates the application of ethnomathematical concepts, where mathematical structures are infused with cultural meaning.

7. Feng Shui Principles in Structural Design

The building's orientation and structural elements adhere to Feng Shui principles, aiming to harmonize the structure with its environment. For instance, the placement of a granite fountain near the east entrance serves to redirect the flow of ch'i, or energy, mitigating the negative effects of a nearby T-intersection. This application of traditional spatial reasoning reflects the integration of cultural practices into architectural planning, a key aspect of ethnomathematics.

Nvivo describes the Technology Integration in Ethnomathematics Learning showed on the Table 1.

Tabel 1. A bar chart showing the number of articles that mention each digital tool.

Tools	Frequency
Augmented Reality	12
Virtual Reality	9
3D Modeling	6
Gamification Elements	3
Mobile Apps	5

Most applications of digitalized ethnomathematics in Taipei 101 were developed for middle and high school mathematics (52%), university-level ethnomathematics courses (28%), and museum exhibitions and public outreach (20%) described in Figure 2.

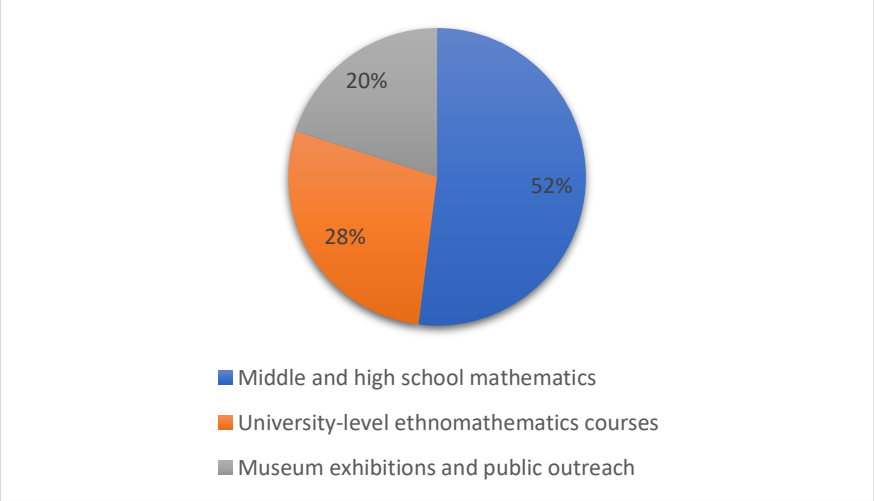

Figure 2. Applications of digitalized ethnomathematics in Taipei 101

Discussion

The results of this systematic literature review reveal that Taipei 101 is more than an architectural marvel—it is a living representation of ethnomathematical knowledge. The tower's design demonstrates a convergence between mathematical reasoning and Taiwanese Chinese cultural traditions. Drawing from D'Ambrosio's (2006, 2018) foundational theory of ethnomathematics, which emphasizes the interplay between culture and mathematical practice, Taipei 101 embodies how localized cultural values, particularly in numerology, geometry, and spatial awareness, can be encoded within modern structures.

One of the most prominent features is the emphasis on the number 8, a symbol of prosperity and good fortune in Chinese culture. The building is divided into eight distinct segments, each with eight floors, which aligns with cultural numerology and also exemplifies mathematical concepts such as modularity and symmetry (Sriraman & Diallo, 2020). These design elements illustrate how cultural symbols can be embedded in structural patterns that are inherently mathematical.

The inspiration for the tower's structure, rooted in traditional pagodas and bamboo stalks, further emphasizes its mathematical significance. These forms reflect scaling, fractal geometry, and recursive patterning—concepts that are essential to mathematical thinking (Huang et al, 2023). Additionally, the use of feng shui in the building's orientation and internal layout illustrates spatial reasoning and geometric alignment principles that are deeply embedded in cultural cosmology (Ju et al, 2016). This supports the claim that ethnomathematical practices are not only abstract traditions but also influence real-world problem-solving and design.

However, these culturally embedded mathematical concepts are often excluded from formal mathematics curricula. Ethnomathematics, despite its growing academic recognition, still faces marginalization in classroom settings dominated by Western mathematical narratives (Lisnani et al., 2025; Rosa & Orey, 2016). By omitting such contextual knowledge, educational systems risk alienating students from culturally diverse backgrounds and missing the opportunity to make mathematics more inclusive and meaningful.

The literature also indicates a need for practical implementation models that integrate ethnomathematical content into the classroom. While researchers have highlighted the theoretical value of such integration (Knijnik, 2002; Barton, 2008), there remains a gap in developing structured curricular resources, especially in the context of modern architecture like Taipei 101. This suggests a direction for future work: to create teaching materials, digital modules, or case-based learning tools that allow students to explore mathematical concepts through culturally relevant examples (Xu & Ball, 2024).

In essence, Taipei 101 provides a compelling case for expanding the epistemological foundations of mathematics education. By acknowledging and incorporating cultural artifacts such as this iconic tower, educators can cultivate a mathematics learning environment that is both contextually rich and globally aware. In conclusion, Taipei 101 exemplifies the rich potential of ethnomathematics to inform and enrich architectural design. By embedding cultural narratives within mathematical frameworks, architects and designers can create structures that resonate deeply with cultural identities while achieving technical excellence (Supriyadi et al, 2022; Supiyati & Halqi, 2020; Suryadi & Suryadi, 2019)

CONCLUSIONS

This systematic literature review has identified that the 101 Tower in Taiwan holds significant potential as an ethnomathematical artifact, blending traditional Chinese numerology, cultural symbolism, and advanced geometric and structural principles. Through its architectural elements—such as its use of the number 8, modular design, and traditional pagoda inspiration—the tower offers multiple entry points for contextualizing mathematical concepts such as geometry, measurement, proportion, and symmetry. However, this potential remains underutilized in formal mathematics education. The review emphasizes the importance of recognizing modern landmarks as sources of culturally contextualized mathematics that reflect indigenous knowledge systems and contemporary design. Present a detailed and reflective analysis of the study's findings, examining their significance and potential impact on your future teaching approaches. Go beyond descriptive statistics and draw conclusions that synthesize the results, interpreting them within the study's theoretical framework.

This study is limited by the scope and availability of academic literature directly addressing the ethnomathematical aspects of 101 Tower in Taiwan. Much of the existing research remains fragmented or focuses predominantly on architectural or cultural perspectives, with limited integration into mathematical pedagogy. Moreover, language constraints may have excluded some relevant sources published in Mandarin or other local dialects. The review also did not incorporate primary data or field studies, which may have provided richer insights into the contextual mathematical practices embedded in the 101 Tower's design and symbolism.

Integrating the ethnomathematical features of 101 Tower into mathematics education presents a valuable opportunity to promote culturally responsive pedagogy. Future curricula can draw upon the structure and symbolism of the tower to teach mathematical concepts in a way that is both engaging and contextually meaningful to learners, particularly in Asian settings. By embedding cultural artifacts into learning materials, educators can foster a deeper appreciation for the interplay between mathematics and culture, enhance student engagement, and support inclusive learning practices (Marlissa et al, 2023; Anisa et al, 2023; Amit & Abu, 2017). Additionally, this study calls for further research and curriculum development efforts that incorporate modern cultural symbols and architecture to bridge formal mathematics and real-world applications. This study holds significant value in bridging the gap between cultural heritage, mathematical understanding, and modern technology through the lens of ethnomathematics. By focusing on the iconic Taipei 101 Tower, a landmark rich in both mathematical structure and cultural symbolism, the research emphasizes how traditional knowledge systems can be preserved and revitalized through digital platforms.

Acknowledgments

The authors would like to express their sincere gratitude to the academic and administrative staff of Universitas Negeri Surabaya for their continuous support and encouragement throughout the research process. Special thanks are extended to the reviewers and editors of the *Journal of Emerging Technologies in Ethnomathematics (JETiE)* for their valuable feedback and guidance, which significantly improved the quality of this article. This research was also made possible thanks to access to digital databases and resources that facilitated the systematic literature review. The authors are also grateful to the scholars whose work laid this study's foundation. Lastly, we acknowledge the contributions of colleagues and peers who offered insightful suggestions while preparing the manuscript.

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