Research Article

Preserving Cultural Heritage with Digital Design and NFT Technologies: Innovative Approaches in Architectural Education

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Abstract

This study explores the integration of Non-Fungible Tokens (NFTs) into architectural education to equip students with the knowledge and skills necessary to thrive in the digital age. By incorporating NFT technology into the curriculum, the study aimed to foster a comprehensive understanding of digital design, intellectual property protection, and the potential of NFTs in preserving and promoting architectural heritage. The research found integrating NFTs empowered students to explore the intersection of art, technology, and commerce within the architectural realm. By transforming their designs into unique digital assets, students developed a deeper appreciation for their work's commercial potential and the importance of intellectual property protection. The study demonstrated the role of NFTs in fostering networking opportunities, enabling students to connect with a wider audience and potential collaborators. To fully harness the potential of NFTs in architectural education, the study emphasizes the need for a holistic approach that addresses ethical, legal, and environmental considerations. Educators must instil in students a strong sense of responsibility regarding the creation and utilization of digital assets, including copyright, licensing, and the environmental impact of blockchain technology. Fostering interdisciplinary collaboration is also crucial for equipping students with the diverse skill set required to navigate the complexities of the digital landscape. By addressing these critical dimensions, architectural education can effectively prepare students to become proficient digital designers and informed participants in the evolving NFT ecosystem. This research contributes to the ongoing discourse on the role of technology in shaping the future of architecture and preserving cultural heritage.

Keywords: Architecture, Architectural Education, Digital Design Studio, Digital Transformation, NFT.

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Araştırma Makalesi

Dijital Tasarım ve NFT Teknolojileriyle Kültürel Mirasın Korunması: Mimarlık Eğitiminde Yenilikçi Yaklaşımlar

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Özet

Bu çalışma, öğrencilere dijital çağda başarılı olmak için gerekli bilgi ve becerileri kazandırmak amacıyla, Değiştirilemez Jetonların (NFT'ler) mimarlık eğitimine entegrasyonunu araştırmaktadır. Çalışma, müfredata NFT teknolojisini dahil ederek, dijital tasarım, fikri mülkiyet koruması ve NFT'lerin mimari mirası koruma ve tanıtma potansiyeli hakkında kapsamlı bir anlayış geliştirmeyi amaçlamaktadır. Araştırma, NFT'lerin entegre edilmesinin öğrencilere mimarlık alanında sanat, teknoloji ve ticaretin kesişimini keşfetme gücü verdiğini bulmuştur. Öğrenciler, tasarımlarını benzersiz dijital varlıklara dönüştürerek, çalışmalarının ticari potansiyeli ve fikri mülkiyet korumasının önemi konusunda daha derin bir takdir geliştirdiler. Dahası, çalışma, NFT'lerin ağ kurma fırsatlarını teşvik etmedeki rolünü göstererek, öğrencilerin daha geniş bir kitleyle ve potansiyel işbirlikçilerle bağlantı kurmasını sağlamıştır. NFT'lerin mimarlık eğitimindeki potansiyelinden tam olarak yararlanmak için çalışma, etik, yasal ve çevresel hususları ele alan bütünsel bir yaklaşıma olan ihtiyacı vurgulamaktadır. Eğitimciler, öğrencilere telif hakkı, lisanslama ve blok zinciri teknolojisinin çevresel etkisi de dahil olmak üzere dijital varlıkların yaratılması ve kullanımı konusunda güçlü bir sorumluluk duygusu aşılamalıdır. Disiplinler arası iş birliğini teşvik etmek, öğrencilere dijital ortamın karmaşıklıklarında gezinmek için gereken çeşitli beceri setini kazandırmak için de önemlidir. Bu kritik boyutlara değinerek, mimarlık eğitimi öğrencileri yetenekli dijital tasarımcılar ve gelişen NFT ekosisteminde bilgili katılımcılar olmaya etkili bir şekilde hazırlayabilir. Bu araştırma, mimarlığın geleceğini şekillendirmede ve kültürel mirası korumada teknolojinin rolü hakkındaki devam eden söyleme katkıda bulunmaktadır.

Anahtar Kelimeler: Mimarlık, Mimarlık Eğitimi, Dijital Tasarım Stüdyosu, Dijital Dönüşüm, NFT.

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INTRODUCTION

Throughout the 20th century, the rapid development of technology has encouraged extensive transformations in various sectors of society, including the field of art. The integration of digital technologies into art has led to paradigm shifts in the creation and perception of art. Particularly in recent years, digital art has started to emerge prominently, replacing traditional physical manifestations. According to Doğan et al. (2022), artists have increasingly embraced digital tools and techniques, significantly changing traditional art methods. These changes enable artists to harness the power of digital environments, acquire new capabilities, and produce works independent of the constraints of space and time. This production process allows designed artworks to be location-independent and readily accessible to a universal audience. In this context, the convergence of art and technology not only expands the boundaries of designed artworks but also facilitates the generation of monetary gains through online platforms and virtual marketplaces, giving rise to new economic models. Moreover, technological advancements give artists unique control over the entire life cycle of digital artworks, including creation, presentation, storage, and distribution.

Simultaneously, through a multitude of digital tools and software, artists can take charge of designing and representing their works without being dependent on any individual or institution. This autonomy contributes positively to the artistic production process and enhances the representation of artworks (Özeren & Qurraıe, 2024). The necessity of presenting digital artworks to art enthusiasts has led to the emergence of virtual galleries, online platforms, and new exhibition spaces that interact with these environments. These platforms facilitate the preservation and security of digital art, ensuring the longevity and accessibility of digital works for future generations. Furthermore, the distribution and dissemination of digital art have undergone new technological transformations as digital artworks can be instantly shared globally through digital platforms and social media networks. This symbiotic relationship has evolved into a structure that fosters cross-cultural dialogue, collaborative initiatives, and increased artistic practices.

In digital culture, the necessity to establish and protect the rights of unique and original creations, particularly for displaying and selling such creations on a global scale, has led to numerous developments. This matter has gained increasing importance and garnered considerable interest in scientific fields. Particularly, the concept of Non-Fungible Tokens (NFT) has emerged as a significant focal point (Doğan et al., 2022). NFT refers to digital assets stored on a blockchain, representing a unique digital entity with no identical counterparts (Fairfield, 2021). An NFT is a singular entity with a unique cryptographic key specific to the respective artwork, functioning as a virtual signature that certifies the creator and current owner (Wang et al., 2021)—additionally, NFT functions as a form of cryptocurrency. However, NFTs differ from traditional cryptocurrencies like Bitcoin in terms of their intrinsic properties (Nakamoto, 2008; Shirole, 2020). Non-Fungible Token (NFT) is a cryptocurrency derived from Ethereum's smart contracts (Wood, 2014). Ethereum is the most popular blockchain used for the creation and sale of NFTs, although other blockchains such as Binance Smart Chain, Polkadot, Flow by Dapper Labs, Tron, and Tezos also exist (Saygın & Fındıklı, 2021). Designers can earn royalties from any successful sale of an NFT in any NFT marketplace or exchange. Although NFTs represent more than just a piece of software code, they attribute commercial value to the digital objects when sold to a new buyer. The apparent IP code for non-fungible virtual assets ensures that the selling prices of relevant products are well secured. As a result,

a guarantee is provided for the exhibition and availability of the artwork (Garay et al., 2020).

Blockchain technology has emerged as a transformative force with extensive applications in various virtual environments, offering robust solutions for data storage, transfer, and asset valuation (Blokzincir Araştırma Laboratuvarı, n.d.). It is decentralized in nature, and cryptographic protocols ensure the security and immutability of digital data, while the distributed ledger system enables transparent and verifiable transactions. Grover et al. (2018), emphasize that blockchain technology serves as a reliable database that protects digital data and facilitates verification and validation of digital processes. These features make blockchain technology an ideal infrastructure for creating and transferring NFTs (Non-Fungible Tokens). Currently, efforts are being made to develop new insights into preserving, storing, and transmitting cultural assets for future generations. This study aims to leverage NFT technologies to preserve cultural assets and their sustainable engagement in socio-cultural and economic domains. Consequently, digital technologies' role in cultural transmission can be identified, and integrating emerging digital technologies into the educational processes can potentially reshape the culture of preservation.

In architectural education, integrating digital technologies into design studio curricula has gained momentum over the past 20 years (Onur, 2022). Educational institutions mainly play a significant role in utilizing digital tools and platforms for preserving and perpetuating cultural heritage and fostering the convergence of cultural heritage and the digital realm (Xi et al., 2022; Özeren & Sultan Qurraie, 2022). Universities and related departments offer specialized education and training programs, especially at the graduate level, focusing on cultural asset preservation, conservation, and digital representation (Yang et al., 2020; Özeren & Dinç Kalaycı, 2022). By incorporating blockchain technology and NFTs into these educational processes, this study's main objective is to enhance students' digital capabilities and ensure the integration of cultural heritage into the digital domain. Consequently, by employing blockchain technology along with original artworks that embody cultural values on a common platform, this study aims to enable educational institutions and stakeholders in the cultural sector to increase the preservation, visibility, and accessibility of cultural heritage beyond geographical and temporal boundaries. Moreover, by integrating NFTs into the educational process, the study aims to create unique digital representations of cultural assets, preserving their authenticity and value, enabling their virtual exhibition and transmission, and inspiring the creation of new artworks regarding these representations.

This study focuses on capturing the historical fabric of Safranbolu City, listed in the UNESCO World Heritage List, through photography and re-interpreting it to create digital patterns. This process digitalizes the existing local identity, creates digital archives, and generates new patterns inspired by the current texture. The ultimate aim is to ensure the sustainable existence of the local identity in the digital world. Additionally, the study aims to help students develop their digital design skills and learn about the potential use of digital technologies in architectural education. The project has encouraged students to enhance their creativity and engage in critical thinking about the role of digital technologies in the future of architecture. Ultimately, it is concluded that digital technologies can improve architectural education and assist students in developing their digital design skills. Furthermore, this project presents new opportunities for students' learning processes by showcasing the potential use of digital technologies in the future of architecture.

Architectural Education Process, Conservation, and Digitization

In the field of architectural education, the digitization of cultural heritage and the convergence of a global common ground hold significant potential in facilitating the transfer of cultural knowledge (Milic et al., 2022). Especially for historically significant and officially registered structures, they play a crucial role in disseminating culture. Urban historical fabric is a valuable component of cultural heritage, and its preservation relies on various professionals, especially architects. Given this, it is impossible for architecture students, trained in understanding and safeguarding historical structures, to be indifferent to a city's cultural heritage (Duru & Şenyiğit, 2023). Through digitization, these cultural heritage elements serve as concrete representatives of our collective place in the world.

Various visualization programs contribute significantly to digitizing cultural assets and transmitting culture in the architectural education process, enabling a more comprehensive exploration of cultural heritage. The digitization process allows individuals to have broader access to historical resources, enabling them to explore the past and establish a profound connection with it. The preservation and digital dissemination of cultural assets enable architectural students to immerse themselves in humanity's shared memory, bridge the gap between the past and the present, and develop a deep sense of cultural identity. Digitizing cultural heritage overcomes temporal and spatial barriers and opens up new ways to engage with and interpret our common heritage. The visualization programs required to present the products can help architecture students re-interpret and analyse historical structures with great attention to detail, providing solutions for complex details that could otherwise be lost over time. Additionally, digitizing cultural heritage facilitates access to historical knowledge, enabling individuals from different backgrounds with various historical and geographic cultures to engage with these valuable resources and learn cultural and historical values (Owens, 2013). Using visualization tools, educators can effectively convey the essence of cultural heritage to students, foster cultural awareness, and establish a deep connection with the past.

This digital approach to preserving cultural values safeguards our architectural heritage and enhances its accessibility, providing future generations with the means to explore, understand, and sustain our rich cultural legacy. Some areas in which the digitization of cultural heritage can be integrated into architectural education include:

- 3D modelling and visualization: 3D models of historical structures can create immersive learning experiences for students. These models can be used to explore both the interior and exterior of buildings from various angles (Yıldırım et al., 2010). Additionally, 3D models can be utilized to create animations of historical structures, helping students understand how these buildings were used and changed over time. Notably, examples can be found in the literature where laser scanning and BIM systems are used together to create models that are combined with technologies like virtual reality (VR) (Sidani, 2021).
- Virtual tours: Virtual tours of historical structures can grant students access to buildings that may no longer exist, such as ancient ruins (McKnight et al., 2016).
- Digital archives: Digital archives of historical documents and images can provide rich information for students to research architectural history, including design processes, materials, construction techniques, and the social and cultural context of architecture (Zağra et al., 2022).

In addition, various examples of NFT usage in cultural heritage and architecture worldwide can be presented. These include:

- Due to the ongoing conflict in Ukraine, many cultural heritage sites are at risk of destruction. In response, the National Art Museum of Ukraine has auctioned 15 NFT designs to raise funds for the continued operations and support of their staff. These NFTs are based on artworks by famous Ukrainian artists like Albrecht Dürer, Georg Jacob Johann van Os, and Ivan Aivazovsky (Murhpy, 2023).
- The renowned Zaha Hadid architecture firm designed a virtual art gallery called "NFTism Gallery" in the metaverse in December 2022. The gallery includes NFTs of various digital art pieces created by artists working on the blockchain. Virtual visitors can explore the gallery and interact with the displayed artworks. NFTism Gallery represents a significant development in the field of digital art and marks a significant step in the metaverse, having a global impact (Stouhi, 2021).
- The American furniture brand Heller has started using blockchain to determine the authenticity of a physical product from its inception to purchase. By making a product's history fully traceable, the company plans to track products throughout their usage lifetimes and assist customers in redistributing or reusing unwanted furniture pieces (Frew, n.d.).

MATERIALS AND METHODS

This study was conducted as part of the Digital Design Studio course offered during the spring semester of 2022 within the Department of Architecture at Karabük University. A single instructor conducted the course. Initially, the course had 50 enrolled students, but some of them were discontinued for various reasons, resulting in 44 students completing the semester. The course carried five credits and lasted for 14 weeks, with 4 hours of class time per week.

Throughout the course, various software training sessions were provided to the students, and they were assigned different projects related to these software applications. One of the projects conducted during the semester was titled "From Ground to Digital," which lasted for eight weeks after the preliminary training.

In the project's first stage, students were taught Advanced Photoshop Techniques using Adobe software, followed by instruction in Adobe Illustrator. For the "From Ground to Digital" project, students were asked to plan and carry out independent field trips to the historical sites of Safranbolu, recognized as a UNESCO World Heritage Site. The specific focus areas for the trips were the bazaars, Kıranköy, and Bağlar locations. During these trips, students were encouraged to explore patterns and textures present in the architectural elements of the site. The scope of the project was limited to architectural structural elements.

These field trips connected the students directly with tangible architectural heritage and allowed them to deeply examine and gain awareness of the intricate details contributing to the city's cultural significance. The photographs taken by the students during the trips were projected in the classroom, transformed into presentations, and analysed during the course.

In the second stage, students were required to select three photographs from their analysed collection and use the software skills they had learned to create new patterns and designs. Throughout this process, the students were expected to gain a deeper understanding of the relationship between traditional architectural elements and their digital representations.

In the third stage, the course introduced concepts such as NFTs (Non-Fungible Tokens) and Metaverse, followed by a presentation by an expert in the field of digital arts. This presentation aimed to provide the students with insights into the details and industry experiences of the online NFT and Metaverse worlds within the context of digital arts.

Figure 1. Classroom photos from Digital Art Installation Architect Ecem Dilan Köse's Metaverse Talks and NFT Art online presentation within the scope of the Digital Design Studio Course.

In the third stage, the students were shown in detail how they could upload the patterns they produced via the Opensea website as NFT, and the students were allowed to do NFT. At the last stage, students' opinions were taken on how the transformation from Earth to Digital can be realized between NFT and metaverse. As a result, with this study, the use of digital technologies in the protection of cultural heritage and transfer to future generations has been experienced in architectural education processes. In this way, the effective role of art and architecture in revealing the identity specific to the place will be revealed, and cultural heritage awareness will be transferred to the students in the education process. The share of digital production in the sustainability of cultures, lifestyles, and traditions will be evaluated. In addition, the importance of using digital technologies in the design processes and then registering the product, which was also revealed with NFT technologies, determining its value, and putting it up for sale, is done within the architectural education process. Thus, there will be a chance to establish an organic link in integrating cultural heritage and the virtual world.

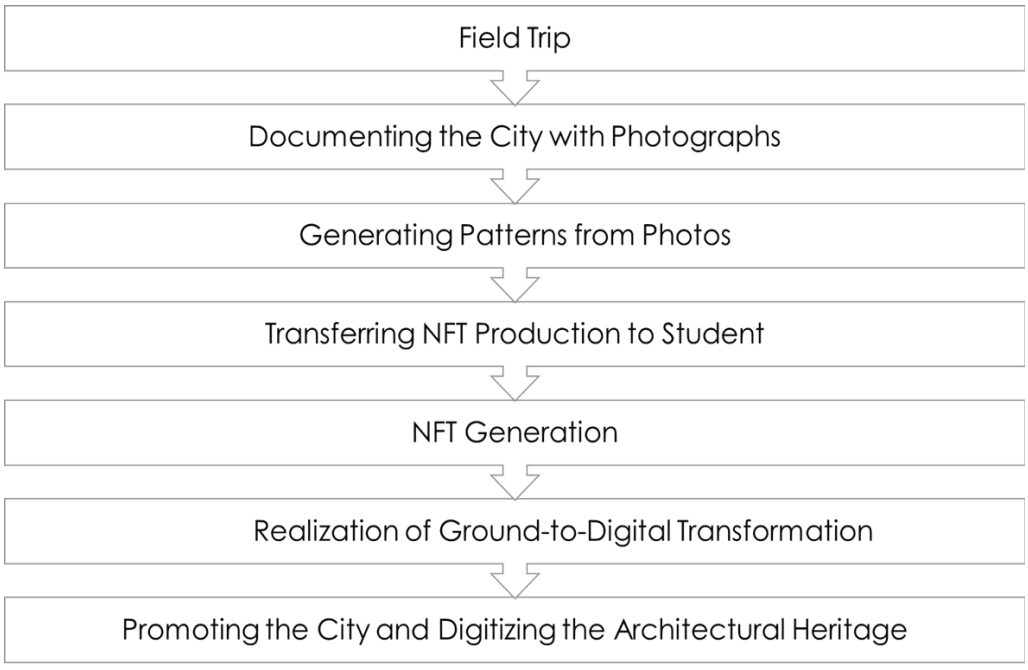

Figure 2. Flow chart of the methodology.

RESULTS AND DISCUSSION

The emergence of digital transformation has had a profound and extensive impact on various disciplines, including architecture (Yetkin & Çoşkun, 2021). To keep up with this transformation, architectural education should aim to equip students with the skills to use digital technologies. Digital transformation in architectural education manifests itself in various ways, particularly over the past two decades, where the use of digital tools in design processes and methods has steadily increased (Erol, 2021). Computer-aided design (CAD), building information modelling (BIM), 3D modelling, virtual reality (VR), and augmented reality (AR) are among the digital technologies that are increasingly integrated into architectural education (Wang et al., 2018). These technologies provide architectural students with faster, more accurate, and more efficient design processes, enabling them to benefit from the advantages of digital transformation.

Moreover, the digital transition in architectural education profoundly influences students' communication and presentation skills. By utilizing visual aids, animations, interactive simulations, and other digital media formats, students can enhance their ability to effectively convey their architectural projects and express their ideas during presentations. This advanced capability to communicate architectural concepts through digital tools significantly contributes to successful project presentations and encourages a high level of architectural representation. Furthermore, the integration of digital tools and internet resources provides students with unique convenience and efficiency in exploring new design concepts and emerging architectural trends from an extensive pool of knowledge. Students who benefit from these digital resources are supported in expanding their design horizons and engaging with architectural innovation at the forefront.

This study delves into the exploration of NFT technology within architectural education. It also evaluates its potential contributions to digitizing architectural history and cultural heritage to enrich students' development. The study focuses on students creating architectural products using 3D modelling tools, drawing inspiration from historical buildings, and subsequently presenting these works as NFTs in digital environments. To illustrate the application of this approach, the study conducted fieldwork in the historical town of Safranbolu, which is listed as a UNESCO Cultural Heritage site. During this process, students extensively studied the existing historical fabric of the town, documenting patterns and motifs through photographs, and gained various perspectives on the town. Building upon these photographs, students demonstrated the courage to produce digital models that offer new interpretations of historical motifs (Figure 2). Subsequently, these digital models were transformed into NFTs, effectively immortalizing and preserving them in the digital world. This experience not only presents the potential of NFTs as transformative tools in architectural education but also enables students to actively engage with architectural heritage and digitalize tangible objects through abstraction by symbolizing architectural patterns and motifs as NFTs, a secure and traceable digital framework was created, contributing to the preservation and dissemination of cultural heritage. Digital technologies not only enhance documentation and conservation processes but also provide an innovative platform for exploring and re-interpreting architectural history. Through their engagement with digital tools and the process of abstraction, students not only focus on the tangible aspects of architectural heritage but also acquire lessons on contributing to its dissemination and preservation in the digital realm.

With this study, the Digital Design Studio course, encompassing software education and theoretical knowledge, provided students with a multidimensional educational experience. The course not only equipped students with the technical skills required for digital design but also fostered an understanding of the significance of preserving cultural heritage in the digital age, as indicated by feedback received. It was observed that this course plays a vital role in shaping students' perspectives on integrating digital technologies into architectural practice and helps them gain a deeper understanding of the complex relationship between architecture, culture, and the digital world. Furthermore, the study within the Digital Design Studio course paved the way for a comprehensive exploration of potential applications of NFT technology and the metaverse in architectural education. By guiding students through creating NFTs and engaging them in discussions about the transition from the physical to the digital world, the course allowed them to explore the intersection of art, architecture, and digital innovation. They were inviting an expert in the field of digital arts to share insights and industry experiences, further enriching students' perspectives on the potential applications of NFTs and the metaverse in architectural design and cultural preservation.

With this study, students have actively engaged in in-depth discussions and debates surrounding the legal and ethical dimensions of intellectual property rights in architecture. The "From Ground to Digital" themed study has provided an effective platform for students to understand the implications and challenges of digitization in architecture education.

During the course, it was observed that students' initial concerns about entering the complex world of NFTs gradually transformed into a sense of confidence. The introduction to NFT technology expanded students' perspectives and sparked curiosity about the emerging Metaverse world. As students delved deeper into the subject, they recognized the potential of NFTs. Some students even embarked on individual research efforts to explore the intricacies and nuances of NFTs. Figure 2 illustrates instances of Designed Pattern Studies created by students.

This proactive engagement allowed students to develop a more nuanced understanding of various applications and consequences of NFTs, extending beyond the technical aspects of creating and implementing NFTs to encompass broader cultural, social, and economic dimensions. Integrating NFTs into the course activities effectively bridged the gap between traditional architectural practice and the digital world, fostering a more intimate and meaningful connection between students and the digital realm. This immersive experience not only heightened their appreciation for the transformative potential of NFTs but also instilled a more profound sense of engagement and representation in the digital space. The increasing curiosity among students indicated the possibility of exploring new approaches to NFTs and related digital subjects in the course. The platform for the Open Sea NFT Sample Collection is shown in Figure 3. This graphic depiction offers information about the layout and user experience of the Open Sea NFT Sample Collection platform, which features a wide variety of non-fungible tokens (NFTs). The picture provides users with a preview of the user interface and the type of tokenized information available inside the Open Sea NFT Sample Collection, acting as a visual help for learning how the platform presents NFTs.

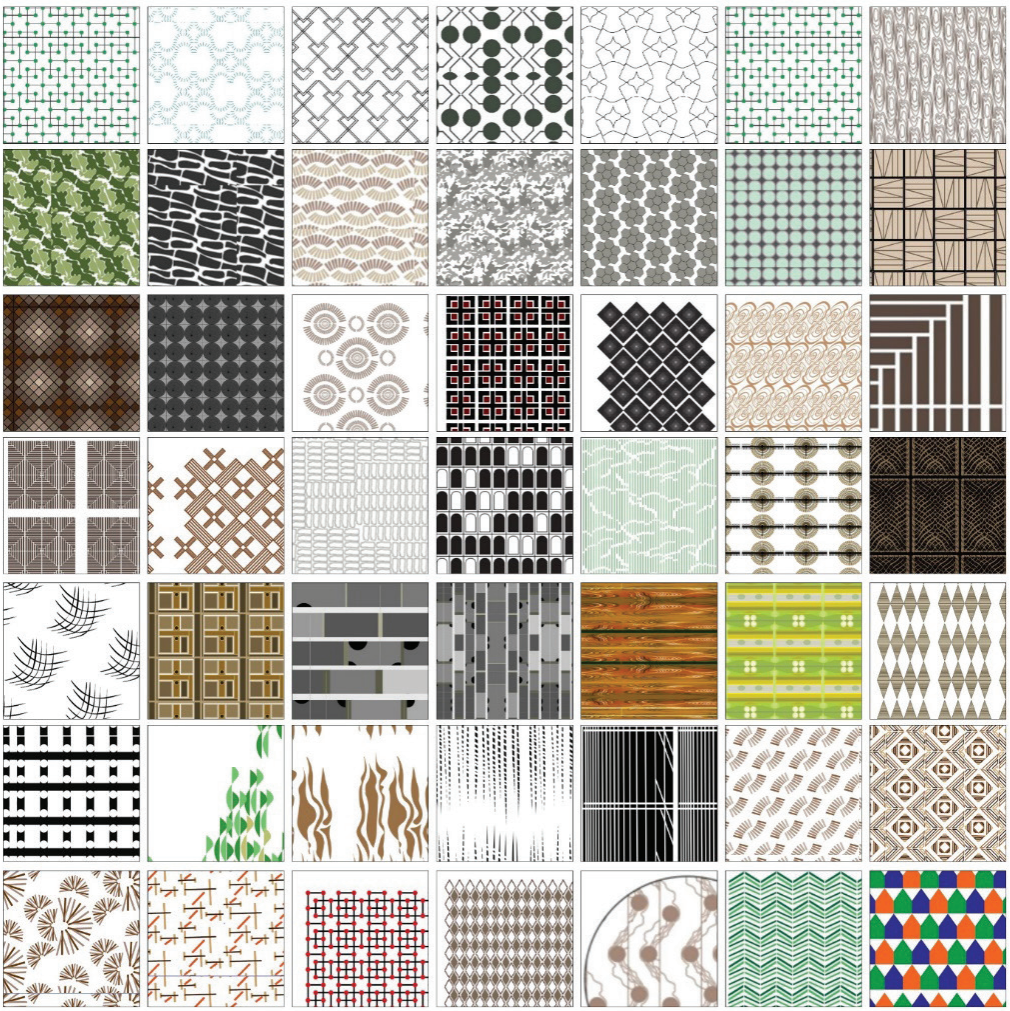

Figure 3. Examples of Designed Pattern Studies.

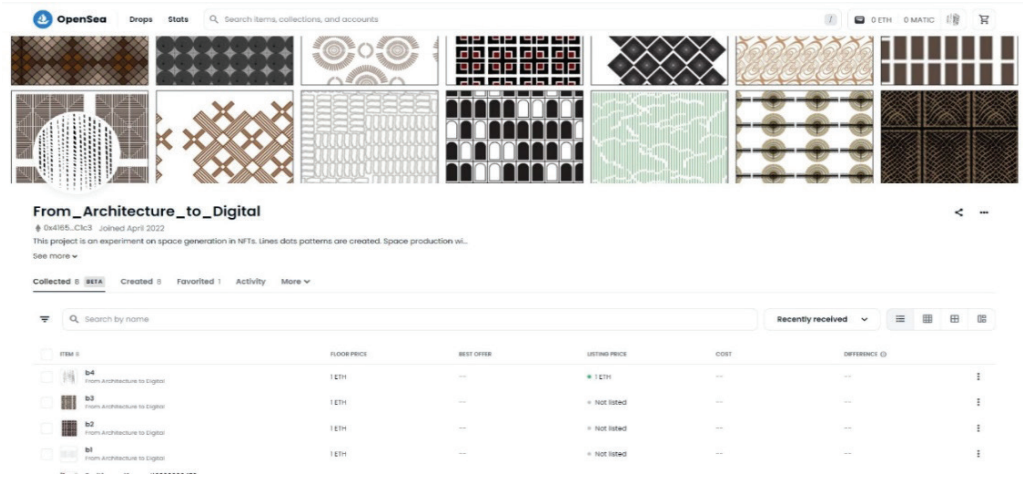

Figure 4. Open Sea NFT Sample Collection.

Students' exposure to different approaches in digital design processes led them to view traditional architecture from diverse perspectives. Students gained insights into the interplay between art and architecture by investigating the potential application of NFTs in architectural design and digital art. Enhancing their skills in digital design processes allowed them to effectively present and enhance their designs' impact and visual appeal in digital environments through the use of relevant software.

Furthermore, the findings of this study suggest that NFTs could be proposed for use in architecture. One such proposal uses NFTs to create digital representations of architectural landmarks and historical buildings, easily shareable and preservable online. Moreover, NFTs can facilitate the digitization of architectural history and cultural heritage and enable students to interact with this material more actively and creatively. Allowing students to create their own NFTs representing architectural patterns and motifs can aid them in developing a deeper understanding of architectural history and culture, potentially leading to a more comprehensive and nuanced comprehension of architectural heritage, which is crucial for the future of the field.

The patterns identified in Safranbolu's architectural fabric offer a valuable resource for architectural knowledge and practice. They serve as a digital repository preserving intricate details, contributing to cultural heritage preservation, and offering a foundation for innovative design concepts. These patterns can be directly applied in architectural projects, from building facades to urban planning, enhancing a sense of place. Additionally, they can inform product design, restoration efforts, and educational initiatives. By analysing these patterns, architects can gain insights into underlying geometric principles and construction techniques. This knowledge can be applied to contemporary design challenges, fostering a balance between tradition and innovation. Moreover, digital archives of these patterns can be used to create interactive experiences, educational tools, and virtual reconstructions, expanding the potential impact of this research beyond the architectural field. Similar to the potential of NFTs to create digital archives of architectural information, these patterns can serve as foundational data for comprehensive digital repositories. By combining the potential of NFTs and the rich pattern language of Safranbolu, architects and researchers can develop innovative ways to preserve, study, and disseminate architectural knowledge for future generations.

CONCLUSION

This experimental case study in architectural education aimed to adapt to the ongoing digital transformation and provide students with a comprehensive understanding of new technologies, mainly focusing on the use of NFTs (Non-Fungible Tokens). The study imparted practical experiences and knowledge about protecting intellectual property to architecture students in digital design processes. By integrating NFT technology into the curriculum, the study observed increased students' awareness of potential advantages and challenges related to this emerging field. Students were educated about the intricacies of NFT technology, including its applications, outcomes, and potential impacts on the architectural profession. Moreover, the study emphasized creating artistic works that combine traditional architectural elements with modern digital techniques. Encouraging students to transform their digitally created architectural projects into unique digital assets that could be commercialized, exhibited, or shared with a global audience has led them to explore the contextual foundations of architecture and its profound connection with the environment. NFTs have had a noticeable impact on empowering students to protect, authenticate, and assert ownership over their architectural designs, resulting in their embracement of NFT technology.

Furthermore, the study introduced students to the networking opportunities provided by NFT technology. Digital galleries and platforms have enabled students to connect with a broader audience, including potential clients, collaborators, and industry professionals. These expanded networks have facilitated idea exchange, feedback, and potential career opportunities,

ultimately enhancing students' professional development and visibility within the architecture community. In summary, this case study has highlighted the transformative potential of NFT technology in architectural education.

To fully integrate NFT technology into architectural education, it is crucial to establish a comprehensive framework that encompasses various dimensions of this emerging field. Additionally, ethical considerations associated with NFTs have been observed. Educators should emphasize the significance of creating and using digital assets, ensuring that students comprehend the ethical implications of tokenizing and selling their works. Moreover, detailed discussions about copyright and legal issues related to NFTs should take place among digital creators. Students need to be aware of the legal framework concerning digital asset ownership, transfer, and licensing. Educators should guide navigating copyright laws, license agreements, and potential risks of copyright infringement when dealing with NFTs. This will assist students in making informed decisions and avoiding legal challenges in their future professional practices. Sustainability is another critical aspect that must be considered while integrating NFT technology into architectural education. While NFTs offer new opportunities for digitizing and preserving cultural heritage, the environmental impact of blockchain technology should not be overlooked. Educators should encourage students to explore sustainable practices in digital art and architecture, such as energy-efficient blockchain networks or alternative technologies with reduced environmental footprints.

Lastly, fostering interdisciplinary collaboration is essential to fully realizing the potential of NFTs in architectural education. Interacting with experts from different fields, such as digital arts, blockchain technology, law, and cultural heritage preservation, can enrich students' understanding and open up new avenues for exploration. Collaborative projects and workshops involving professionals from diverse disciplines can give students a holistic perspective on the possibilities and challenges of integrating NFT technology into architectural practice. By addressing these aspects in architectural education, NFT technology can be embraced responsibly and with foresight. Students will acquire technical skills and develop critical thinking, ethical awareness, and a broader understanding of social, cultural, and environmental impacts. This will prepare them to navigate the evolving digital landscape and contribute positively to preserving and advancing architectural heritage in the digital era.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. No conflict of interest was declared by the authors.

Authors' Contributions

The authors contributed equally to the study.

Financial Disclosure

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Ethics Committee Approval

Ethics committee approval was not required for this article.

Legal Public/Private Permissions

In this research, the necessary permissions were obtained from the relevant participants (individuals, institutions and organizations) during the survey, in-depth interview, focus group interview, observation or experiment.

REFERENCES

Blokzincir Araştırma Laboratuvarı. (n.d.). *Ulusal Blokzincir Çalıştayı. TÜBİTAK BİLGEM UEKAE*. Retrieved May 1, 2022, from https://blokzincir.bilgem.tubitak.gov.tr/1-ulusal-blokzincir-calistayi/

Dore, C., & Murphy, M. (2012, September 2-5). *Integration of Historic Building Information Modeling (HBIM) and 3D GIS for recording and managing cultural heritage sites* [Conference session]. 18th International conference on virtual systems and multimedia (IEEE), Milan, Italy.

Doğan, B., Ersöz, S. Ş., & Şahin, C. (2022). Crypto Art and NFT. *Journal of History Culture and Art Research, 11*(1), 1-12. http://dx.doi.org/10.7596/taksad.v10i4.3127

Dursun, N. (2021). NFT/kripto sanat ve hareketli grafik ilişkisi. *Sciences, 7*(40), 1037-1055. http://dx.doi.org/10.31589/JOSHAS.649

Duru, A. M., & Şenyiğit, Ö. (2023). A study on gathering the opinions of architecture students to enhance user interaction with historical urban fabric: a case study of Tepebağ neighborhood in Adana province. *DEPARCH Journal of Design Planning and Aesthetics Research, 2*(2), 155-171. https://doi.org/10.55755/DepArch.2023.21

Erol, K. (2021). Venedik mimarlik bienali üzerinden deneysel mimaride bilgisayar destekli tasarim etkilerinin okumasi. *Tasarım Enformatiği, 2*(2), 65-74. https://dergipark.org.tr/en/pub/te/issue/66501/869947

Fairfield, J. A. T. (2021). Tokenized: The law of non-fungible tokens and unique digital property. *Indiana Law Journal, 97*(4), 1-54. https://www.repository.law.indiana.edu/ilj/vol97/iss4/4

Frew, S. (n.d.). *NFTs in architecture: how non-fungible tokens are changing design practice*. Architizer. Retrieved May 14, 2023, from https://architizer.com/blog/inspiration/industry/nfts-architecture/

Garay, J.A., & Kiayias, A. (2021, May 17-20). *A consensus taxonomy in the blockchain era* [Conference session]. Cryptographers' Track at the RSA Conference, San Francisco, USA. https://doi.org/10.1007/978-3-030-40186-3_13

Grover, P., Kar, A. K., & Vigneswara Ilavarasan, P. (2018, October 30-01). *Blockchain for businesses: a systematic literature review* [Conference session]. 17th IFIP WG 6.11 Conference of Challenges and Opportunities in the Digital Era. Kuwait. https://doi.org/10.1007/978-3-030-02131-3_29

Milic, R. J., McPherson, P., McConchie, G., Reutlinger, T., & Singh, S. (2022). Architectural history and sustainable architectural heritage education: digitalisation of heritage in New Zealand. *Sustainability, 14*(24), 16432. https://doi.org/10.3390/su142416432

McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2016). Teaching in a digital age: How educators use technology to improve student learning. *Journal of Research on Technology in Education, 48*(3), 194-211. https://doi.org/10.1080/15391523.2016.1175856

Murhpy, J. (2023, October 18). *Daily digest: Yayoi Kusama and Kiki Smith will design installations for Grand Central Madison, Kharkiv Art Museum launches NFT collection, and more*. The Architect's Paper. https://www.archpaper.com/2022/10/daily-digest-yayoi-kusama-kiki-smith-grand-central-madison-

kharkiv-art-museum-nft-collection-more/

Nakamoto, S. (2008). *Bitcoin: A peer-to-peer electronic cash system*. Tech. rep., Manubot Press. https://doi.org/10.2139/ssrn.3440802

Onur, B. (2022). Concept as the activist of creativity in architectural design: exploring factors affecting concept formation using the structural equation model. *Periodica Polytechnica Architecture, 46*(1), 121-132. https://doi.org/10.3311/PPar.19143

Onur, B. (2022). Modern trends in the digital age of architectural learning. In A. Çabuk & H.S. Aşıkkutlu (Eds.), New trends in architecture, planning and design (pp. 5-13). Duvar Publications.

Owens, T. (2013). Digital cultural heritage and the crowd. *Curator The Museum Journal, 56*(1), 121-130. https://doi.org/10.1111/cura.12012

Özeren, E., & Dinç Kalaycı, P. (2022). Mimari tasarım stüdyolarının bibliyometrik veri analizi üzerine bir okuma. In A. Çabuk & H.S. Aşıkkutlu (Eds.), New trends in architecture, planning and design (pp. 113-136). Duvar Publications.

Özeren, E. B., & Qurraıe, B. S. (2024). Sinematik ilhamın grafik, mimarlık ve moda tasarımı eğitimine etkisi: soyut kavramların somut çıktılara dönüşümünde disiplinlerarası yaklaşımlar. *Online Journal of Art and Design, 12*(4), 1-12. http://adjournal.net/articles/124/1241.pdf

Özeren, Ö., & Sultan Qurraie, B. (2022). Evaluation 0f architectural students'thoughts on transformation and reuse projects using ahp method. In M.T. Kayılı (Ed.), Transformation in architecture (pp. 173-191). Generis Publication.

Saygın, E. P., & Fındıklı, S. (2021). Tuvalden tuşa: Sanat pazarındaki dijital dönüşümde NFT'lerin rolü. *Business & Management Studies: An International Journal,* 9(4), 1452-1466. https://doi.org/10.15295/bmij.v9i4.1930

Shirole, M., Darisi, M., & Bhirud, S. (2020). Cryptocurrency token: An overview. In D. Patel, S. Nandi, B. K. Mishra, D. Shah, C. N. Modi, K. Shah & R. S. Bansode (Eds.) *Proceedings of the International Conference on Blockchain Technology* (pp. 133–140). Springer.

Sidani, A., Dinis, F. M., Sanhudo, L., Duarte, J., Santos Baptista, J., Pocas Martins, J., & Soeiro, A. (2021). Recent tools and techniques of BIM-based virtual reality: A systematic review. *Archives of Computational Methods in Engineering, 28*(2), 449-462. https://doi.org/10.1007/s11831-019-09386-0

Stouhi, D. (2021, December 2). *Zaha Hadid Architects presents virtual gallery exploring architecture, NFT's, and the Metaverse*, Archdaily. https://www.archdaily.com/972886/zaha-hadid-architects-presents-virtual-gallery-exploring-architecture-nfts-and-the-metaverse

Wang, P., Wu, P., Wang, J., Chi, H. L., & Wang X. (2018). A critical review of the use of virtual reality in construction engineering education and training. International *Journal of Environmental Research and Public Health. 15(*6), 1204. https://doi.org/10.3390/ijerph15061204

Wang, Q., Li, R., Wang, Q., & Chen, S. (2021). Non-fungible token (NFT): Overview, evaluation, opportunities and challenges. *ArXiv preprint arXiv:2105.07447*. https://doi.org/10.48550/arXiv.2105.07447

Wood, G. (2014). Ethereum: A secure decentralised generalised transaction ledger. *Ethereum project yellow paper,151*, 1–32.

Yıldırım, T., Yavuz, A. Ö., & İnan, N. (2010). Mimari tasarım eğitiminde geleneksel ve dijital görselleştirme teknolojilerinin karşılaştırılması. *Bilişim Teknolojileri Dergisi, 3*(3),17-26. https://dergipark.org.tr/tr/pub/gazibtd/issue/6620/87945

Yang, X., Grussenmeyer, P., Koehl, M., Macher, H., Murtiyoso, A., & Landes, T. (2020). Review of built heritage modelling: Integration of HBIM and other information techniques. *Journal of Cultural Heritage, 46*, 350-360. https://doi.org/10.1016/j.culher.2020.05.008

Yetkin, E. G. & Coşkun, K. (2021). Endüstri 5.0 (Toplum 5.0) ve mimarlık. *Avrupa Bilim ve Teknoloji Dergisi, 27*, 347-353. https://doi.org/10.31590/ejosat.969631

Zağra, H. Ç., Günaydin, D. H. & Özden, S. (2022). Arşiv belgelerindeki mimari çizimlerin dijitalleştirilmesi: Çatalca savunma yapıları örneği. *KAPU Trakya Mimarlık ve Tasarım Dergisi, 2*(2), 85-104. https://dergipark.org.tr/tr/pub/kapu/issue/73706/1162894

Xi, W., & Cong, W. (2022). Remote practice methods of survey education for HBIM in the post-pandemic era: case study of Kuiwen Pavilion in the temple of confucius (Qufu, China). *Applied Sciences, 12*(2), 708. https://doi.org/10.3390/app12020708

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