Blending Lines: Interactive Experiences with Arab Culture

By

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ABSTRACT

This thesis examines the integration of Islamic geometric patterns and traditional Kufic calligraphy into contemporary interactive design. The work highlights the historical and cultural significance of Islamic geometric patterns as a cornerstone of Arab identity while exploring the intellectual and spiritual depth embodied by traditional Kufic calligraphy. By bridging Arab cultural heritage with modern design practices, the work seeks to foster audience engagement and increase awareness of this rich culture and history. Designed to engage diverse audiences with Arab culture through traditional and contemporary approaches, the thesis culminates in an immersive experience that blends physical and digital installations. The physical installations are comprised of three hand-crafted wooden geometric motifs integrated with Kufic calligraphy written by macrame cords. The wood and cotton cords demonstrate the Arab appreciation of natural materials, as nature has been the primary source of inspiration in the Arab world. The digital installations complement this by using projection, light, and patterns to

display large-scale graphics on an adjacent wall. With ultrasonic sensors and a Raspberry Pi, the installation creates an interactive experience where digital projections respond to visitors' movements through the space by shifting colors and patterns. This interaction is crucial; as learning evolves through participation and reinterpretation, this exhibition aims to engage people similarly. Through this research, the thesis underscores the power of design as a medium for education and cultural connection, mainly as it generates connections between tradition and innovation.

Blending Lines: Interactive Experiences with Arab Culture

A Thesis

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By

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DEDICATION

First and foremost, I would like to express my gratitude to God Almighty for giving me the strength and guidance I needed to complete this research.

To my husband and life companion, Ahmed, who supported and encouraged me every step of the way right up to the final moment. To my children, Malek and Mecca, for enduring the challenges alongside me, offering their help when I was immersed in my studies, and always giving me love, kindness, and encouragement.

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I extend my heartfelt thanks to Seo Eo, whose endless support and mentorship have been with me from the beginning of my studies to the final steps of this journey. Also, I am thankful for my colleagues, whose collaborative spirit and insightful critiques have continually enhanced my projects. To each of you, I profoundly appreciate your contributions, which have enriched my academic and creative growth in different ways.

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CONTEXT

Historical Overview of Kufic Script and Islamic Patterns

Origins and Evolution

Arabic and its script gained significant and notable prominence as the Quran language with the ascendancy of Islam in the 7th century. Arabic quickly expanded its reach from Spain to India over centuries. By the late seventh century, the position of Arabic as both a sacred and imperial language developed sophisticated calligraphy, a form of artful writing that initially emerged in architectural inscriptions (Figure 1) and Quranic manuscripts. This led to the evolution of various refined scripts. Many of these scripts continue to be practiced today (Saba, 2021). The most significant types of Arabic Calligraphy are Al-thuluth, Farisi, Diwani, Ruq'a', Alnaskh, and Kufic fonts.

Figure 1: *Minbar and mihrab of the mosque of Ahmed al-Byrdayni in Cairo, Egypt*

One of the most interesting Arabic calligraphies is Kufic. As in all types of languages, it is important to understand that Arabic calligraphy is deeply affected by its regions' culture, religion, and social norms (Aamna, 2020). The initiation of the Kufic style is attributed to the construction of the Dome of the Rock (George, 2010). As Arabs invaded new territories, they were exposed to the marvels of other past and contemporary empires, namely the Byzantine, Sassanid, and Constantinople, which had a rich heritage of art and architecture. In the construction of the Dome of the Rock, motives (Figure 2) and calligraphy with the mosaic craft were used for interior decoration.

Figure 2: *The inner face of the arcade, Dome of the Rock, Kufic writing style.*

Since the mosaics were composed of cubic pieces, they regulated and, for the first time, transformed the Arabic language into a highly angular aesthetic of the Kufic script. The Kufic script quickly became popular and was used for Quran manuscripts, coinage, and milestone signage. The Kufic script remained dominant for centuries, as it alone has nineteen different styles (George, 2010, p. 16).

Kufic calligraphy was the art often incorporated into different compositions that could be representational or abstract. During the ninth century, Kufic script on Fatimid plates and monuments in Cairo was similar to what was found on buildings and objects all around the Islamic empire. In these works, the balance had generally shifted from readability to visibility, as the intention was to make onlookers appreciate the script more for its shape than for its legibility (Shehab, 2020).

The Islamic geometric pattern is another widely recognized visual tradition from the Arabic world. One of the earliest Islamic buildings is the winter balance of Khirbet al-Mafjar, known as Hisham's Palace. It was built between 724 and 743 by the first Islamic dynasty, the Umayyads, near Jericho (Green, 2020). It illustrates the artistic and architectural style and taste of the early Islamic rulers who commissioned its construction. The structure contains extraordinary decorative mosaics, stucco decoration, and one central architectural feature. The geometric mosaic compositions are larger than any other mosaics that have survived since the 8th century and demonstrate the presence of Syrian craftsmen who were renowned for making mosaics in the Roman tradition.

A round stone window now dominates the site of Khirbat al-Mafjar (Figure 3). Archaeologists found its stone elements at the base of a stairwell of the bathhouse; it would have been set in a wall. This feature is important to the early history of Islamic geometric design because it demonstrates its pre-Islamic influences and indicates its future direction. The window is sixfold and set in a circle. The decorated stone elements suggest that the window is constructed from a single interlacing band. This theme of interlacing bands is directly borrowed from the visual language of ancient Roman

mosaics, which used interweaving bands to tie the elements of a composition together. Where the stone window can be seen to anticipate the future of Islamic design is in how a single, relatively simple, design element has been elevated and transformed into a stand-alone feature. This suggests an important and new appreciation of geometric design and its possibilities. Other buildings of the same era reinforce this impression of a novel appreciation of geometric design and an exploration of its possibilities.

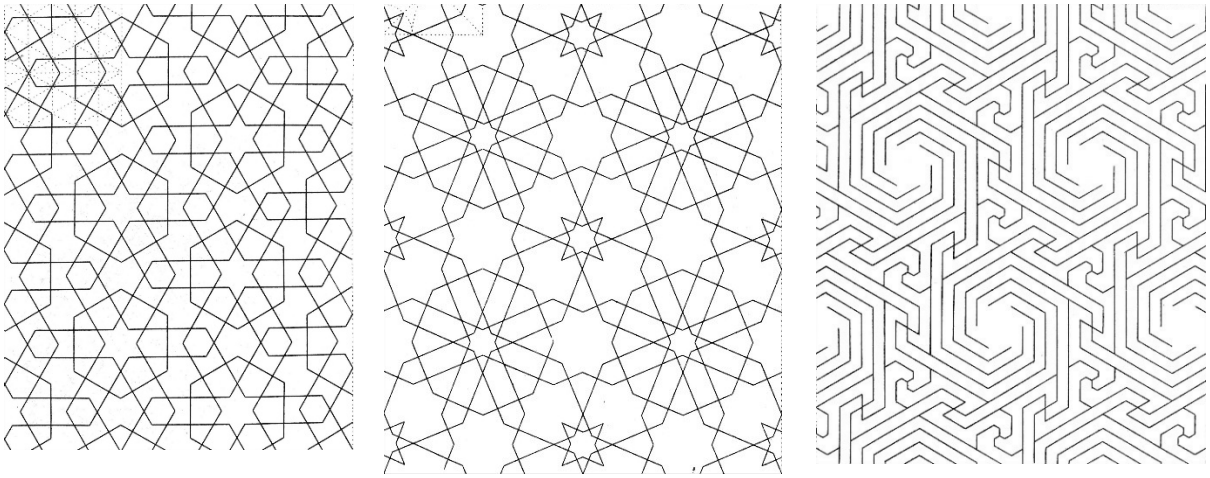
Figure 3: *Round Stone window at Khirbat al-Mafjar, (Hisham's Palace), near Jericho*

Some of the most creative geometric designs in Islamic history were made in environments that were supportive of science and arts. Indeed, 9th- and 10th-century Abbasid Baghdad is a good example of this. Baghdad saw an extraordinary intellectual flourishing of the arts and sciences in this period; Abbasid Caliph al-Mutadid (ruled 892–902) established a school at his court for the teaching of all crafts and the various branches of theoretical and practical sciences. A Baghdad scholar named Abu'l Wafa' al-Buzjani gave geometry classes to artists and builders. One of his students is thought to have written the book *On the Geometric Constructions Necessary for the Artisan*. However, such an environment with a documented joint scientific and artistic

interrogation of geometry and geometric design is exceptional. We cannot conclude that the Abbasid school and the geometry manual are evidence that science spurred craftsmen to create geometric designs. It is more likely that the scientific and craft preoccupation with geometric design took place concurrently and that the scholars took an interest in documenting and analyzing the work of the craftsmen (and possibly explaining it back to them in terms of calculations and angles (Brough, 2013).

The most important characteristic of the aesthetics of Islamic design is its dedication to the principles of symmetry. Most cultures use symmetry to varying degrees to produce different effects. But no other place emphasizes symmetry so consistently across a full range of artistic productions and various materials (Wichmann, 2017). This aesthetic response is derived from the deep thinking of Arab artists about the basic principles of existence, and this explains the philosophy of Islamic art in using geometric shapes as a primary element in its compositions. The three main constructions of all Islamic geometric patterns are based on dividing the circle into fourfold, fivefold, or sixfold. The shapes that can construct these three circles are divided into eight categories according to the fundamental geometric figures from which they spring: hexagon designs, octagon designs, dodecagon designs, a combination of stares or rosettes having two different numbers of points, a combination of squares and octagons, combinations of the stars or rosettes of three or four types, heptagon designs, and pentagon designs (Figure 4) (Bourgoin, 1973).

Figure 4: *Categories of Islamic Geometric Patterns*



Hexagon designs Octagon designs Dodecagon designs

Traditional Applications and Materials

The decorative arts in Islamic Arabic culture are distinguished by their stylistic consistency across various materials and crafts, tracing back to pre-Islamic times. This consistency, combined with local artistic influences, creates a rich tapestry of variations on Islamic art themes (Wichmann, 2017). Geometric compositions can be seen not just on buildings but also on ceramics, metalwork, coins, manuscript paintings, Qur'an pages, woodwork, and many other material objects. Sometimes, people are depicted on these objects wearing garments with geometric patterns (Broug, 2013).

In the Persian/Iranian sphere, brick is the primary building material, while in regions like Egypt, Syria, and Asia Minor, stone is more commonly used. The earliest Islamic monuments continue the Roman/Byzantine tradition of using dressed and carved stone, which evolved into distinct styles under various dynasties, including deep

carvings with calligraphic and geometric motifs. Brickwork, especially in the eastern Islamic provinces of Iraq and Iran, evolved from structural to decorative, showcasing a progression towards greater decorative complexity. This includes a variety of brick bonds and the introduction of glazed bricks, leading to a new era of architectural ornamentation with colored glazed bricks that resemble tiles. The woodwork was highly valued and showcased exquisite craftsmanship, particularly in religious settings. Book illumination, originating from late 10th-century Qur'an manuscripts, exemplifies the Islamic decorative canon, blending calligraphy with geometric and vegetal arabesque designs. This art form influenced other media and played a significant role in transmitting decorative styles across the Islamic world (Wichmann, 2017).

Arabic Calligraphy: Reviving Heritage

Arabic calligraphy declined from a stylistic standpoint to a small number of fonts over time, stylistically, for more than a thousand years. This is due to the introduction of digital technology, so classical calligraphy lost its leading role in the visual arts. The situation worsened due to wars, mass immigration, and colonialism in the Arab world, which led to the loss of libraries and archives in the Arab world. This, in turn, led to a weak connection between artists and their cultural and Arab heritage, of which the visual aspect is an important aspect (Shehab, 2020). Despite this decline, a group of artists and graphic designers have revived Islamic geometric designs and Kufic script in a contemporary way. For example, Egyptian graphic designer Ghada Wali created a project called “Let’s Play!” (Figure 5) to help teach young students and foreigners the Arabic alphabet with a fun simple tool “Lego blocks.” Quartz’s Abdi Latif Dahir says, “With Let’s Play, Wali created a full Arabic abstract display typeface through playfully

building each letter using colored Lego blocks" (Enterprise, 2017). The printed book of letters included explanations and pronunciations of each letter, combined with their Latin equivalent, and a dictionary of 400 words.

Figure 5: *Let's Play Project by Ghada Wali*

Digital Platforms and Interactive Technologies

The Importance of Interactive Technologies and Immersive Experiences

Technology in visual art and design can improve the museum experience by supporting the design of immersive exhibits and creating new ways to engage visitors through sensory-based interactions such as physical movement, touch, sounds, and so on. Harada explains that a visitor's experience while interacting with exhibits should reach all the senses – vision, hearing, touch, smell, and taste (Harada, 2018). A well-designed exhibition can spark curiosity, enhance the learning experience for visitors,

and transform the entire museum into a fun and learning space for cultural, historical, or scientific exploration.

The museum exhibition design plays a crucial role in enhancing user experience. One of the best strategies to help museums offer more targeted experiences through personalized content is designing interactive experiences with technologies like touchscreens and gesture recognition, which allow visitors to engage with customized exhibits. These strategies provide personalized interactive games or tasks to stimulate visitors' interests and curiosity. For instance, The Museum of Modern Art (MoMA) in New York has touchscreen areas where visitors can dive into the stories behind artworks. In addition, creating Multisensory Experiences using audio, aroma, touch, and other multisensory elements enhances visitors' perception of exhibition content. By introducing visual, auditory, tactile, olfactory, and gustatory elements, with attractive colors, lighting effects, sounds, aromas, etc., museums can stimulate visitors' interest and emotions, creating a long-lasting experience. Specific implementations include audio content and allowing tactile interaction with exhibits, providing visitors with a richer sensory experience. The Los Angeles County Museum of Art grabbed a diverse audience's attention with its multisensory exhibit, "Rain Room," creating a unique experience where visitors could walk in the rain without getting wet (Huang, 2024). (Figure 6)

Figure 6: *Rain Room Interactive Exhibition, Los Angeles County Museum of Art, by Hannes Koch*

Using Technologies in Cultural and Artistic Contexts

In the context of digital platforms and interactive technologies applied within cultural and artistic environments, the exhibition *Ideas of Switzerland* (Figure 7) at the National Museum Zurich serves as an influential case study. Notably, it enhanced the use of technology through four interactive books developed by Iart Studio. These books allow visitors to engage directly with historical documents and narratives, providing tangible links between Switzerland's past and its contemporary identity. Through the act of leafing through these interactive volumes, attendees are not merely passive observers but active participants in exploring and understanding the concept of Switzerland today. Visitors learn about how people in Switzerland vote and the unique

aspects of their militia system. They also discover what results from their hard work and careful attention to detail and how Switzerland shows itself to the rest of the world, even though it's neutral. The interactive books at the exhibition tackle these topics with fun, short animations. This makes topics like politics, the economy, science, and foreign relations easier and more fun to learn about. Visitors can playfully explore these subjects, making them feel lighter and more interesting (Iart, 2016). This example has significant potential for digital platforms and interactive technologies to transform traditional museum experiences and strengthen a deeper connection between historical content and modern audiences in cultural and artistic contexts.

Figure 7: *The exhibition 'Ideas of Switzerland' at the National Museum Zurich*

Relevance

The Importance of Learning Diverse Cultures

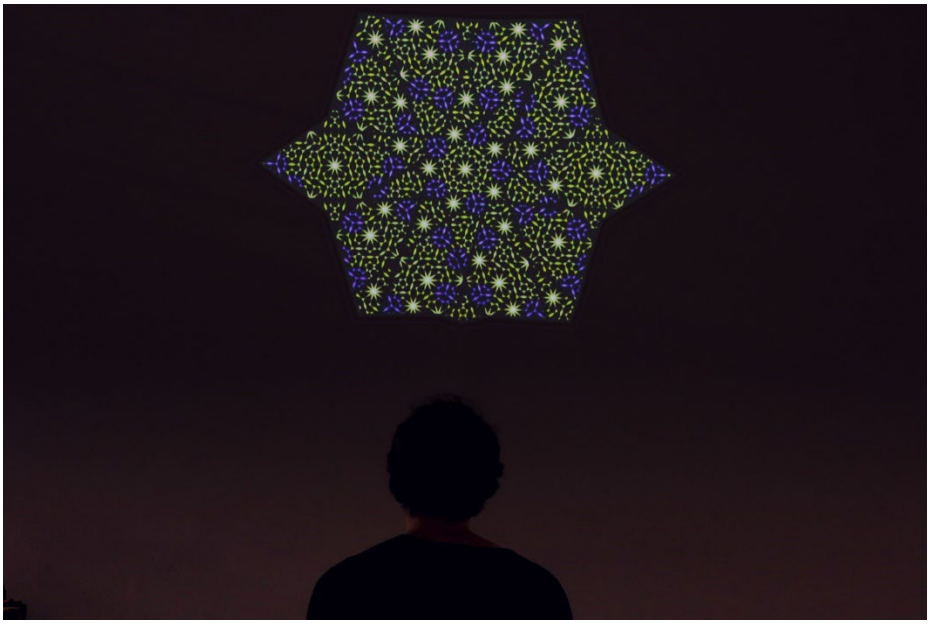
In today's world, diversity plays a vital role in our lives. This diversity requires us to try to get to know each other and bring our ideas closer. This leads to an increase in understanding and acceptance of others. As Hammond (2007) emphasizes in his book Popular Culture in the Arab World: Arts, Politics, and the Media, Arab culture should be presented from multiple perspectives beyond the political, allowing us to build cross-cultural bridges.

One of the most effective ways to gain insight into a culture is through its art styles and design directions. Visual language transcends language barriers and offers a powerful, emotional connection to the experiences that support the cultural context. Bishop discusses how participatory and interactive art forms offer an accessible and engaging way for people to immerse themselves in different cultural contexts (Bishop, 2022). The focus of this research is engaging diverse audiences with Arab culture.

The use of Arabic language and Islamic design basics by graphic designers is considered an effective way to express and engage Arabic culture with diverse audiences. Khaled identified in 2000 in his research on Arabic calligraphy that it is one of the essential artistic forms for the visual expression of Islamic and Arab creativity. It expresses the development of this civilization throughout history and its geographical spread in the Islamic world. It also reflects the cultural values of the Arab Islamic world (Alashari, 2019.)

Many designers who are interested in culture sharing and engaging audiences with their designs are creating immersive interactive experiences, whether in digital or physical platforms. These experiences are multi-sensory and activate multiple senses: sight, sound, touch, and smell, to create emotional and intellectual connections with participants. When the main purpose of the experience is engaging in another culture with a diverse audience, these multi-sensors will make the culture learning more accessible and personally involved. For example, the designer Haleem ul Hassan created a project called ZUHUR 2016, an interactive Islamic Art Experience for sharing Arab and Islamic culture (Figure 8). He stated that “this project is a modern implementation of Islamic art, in the hopes of increasing its awareness, appreciation, and beauty to the public, as well as to designers and craftsmen. The goal was to create an immersive experience for myself and others in which we get lost in the beauty of these geometric patterns. With the help of an application, users make their own patterns and see them live on a wall via projection mapping. They saved their creations in the end, which were sent to them in a high-quality digital format.” This digital interactivity that gives space to users to choose and create their own patterns and colors and take a copy of the result helps engage the audience with this type of art, “Islamic geometric patterns,” and profoundly learn this culture.

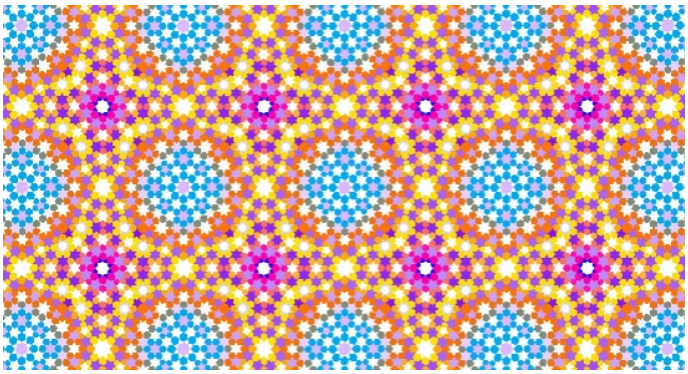
Figure 8: *ZUHUR, an interactive Islamic Art Experience by Haleem ul-Hassan*



In the immersive experiences that present Islamic design elements through interactive technologies, one notable example is the project “Quasicrystal” by Toby Schachman in 2017. This innovative series encompasses three audio-reactive visual patterns that utilize GLSL within the open Frameworks environment. The patterns draw inspiration from the groundbreaking research conducted by Peter J. Lu, a researcher at Harvard, who explored the intricate connections between quasicrystals and the Islamic tilework adorning the Darb-e-Imam mausoleum, as well as the broader tradition of tilework across the Middle East. Schachman's work stands as proof of the relationship between traditional Islamic art and contemporary digital creation, offering a modern interpretation that enriches our understanding of both fields through the lens of immersive technology (Schachman, 2017).

Another example that illustrates the incorporation of Islamic art with modern technologies is the project “Sharjah Spectrum” by artist Zara Hussain. As seen in (Figure 9), her project was installed across three walls at the Sharjah Art Museum in December 2015. The piece had music composed especially for it, and participants could choose the colors in the gallery with their mobile phones. The color choices were updated via WIFI every 20 seconds. The computer code makes a random color choice when no choices are made. The animation loops infinitely. She created the code in a way that rarely will the same color and time sequence ever repeat. Hussain's project profoundly explores the intersection between spirituality, technology, and art. She draws upon the rich Islamic tradition of mathematics, a discipline that early Muslim mathematicians excelled in, to develop algorithms that animate traditional Islamic designs. Hussain was inspired by a design she observed on a mosque in Iran and aimed to reinterpret the traditional techniques used to create such patterns through the lens of contemporary technology. By doing so, she proved how traditional Islamic heritage and modern coding techniques can combine to produce fascinating animations that respect the past while compatible with the future (Hussain, 2015).

Figure 9: *Sharjah Spectrum by designer Zara Hussain*



Research Method

Research Questions

Building on the literature review, which explores the historical decline and contemporary revival of Arabic calligraphy and Islamic geometric patterns, this section delves into the role of interactive computer technology in this context. While previous studies highlight the significance of preserving and reimagining traditional design elements, there is a need to understand how modern technological approaches can enhance audience engagement with Arab cultural heritage. The coming thesis research questions is to address this gap:

1. How can digital technologies and tools effectively create immersive experiences that showcase traditional Islamic geometric patterns and Kufic calligraphy?
2. What are the challenges and opportunities in integrating tangible formats with digital interactive installations?
3. How do audiences respond to the traditional Arabic design elements with contemporary interactive technology in a cultural context?

To address these research questions, this thesis developed a multifaceted approach that blends traditional and modern elements. This approach was to create an immersive experience exhibition that contains both physical and digital components, physical and digital. These two sides of the project interacted together to firmly engage the visitors with the tradition of the Arabic and Islamic geometric patterns and Kufic calligraphy, not only by using traditional material, which is wood and macrame cords but also by adding a digital installation that is interacting with the present of the visitors

around the exhibition. This installation represents the logic of the complex patterns and the inner beauty of this tradition.

Research Objectives

To guide the exploration of these research questions, a set of objectives was established to ensure a systematic approach. These objectives aim to bridge the gap between traditional Arabic design elements and contemporary interactive technology, focusing on Arab cultural engagement. This list of objectives is as follows.

1. Understand how current digital platforms, software, and hardware sensors are used in creating immersive experiences, particularly those involving cultural and artistic elements.
2. Investigating how Islamic geometric patterns have been incorporated into contemporary digital and tangible interactive designs.
3. Create an interactive installation that combines software, hardware sensors, tangible woodcarving, and macrame threads to showcase traditional Arabic design elements in an immersive way.

Research Outcomes

The research objectives outlined above provide a clear framework for exploring the integration of traditional Arabic design elements with contemporary interactive technologies. The following section presents the outcomes of this research, highlighting the project's key findings and contributions.

The process of creating this interactive immersive exhibition started first by conducting research on how current digital platforms, software, and hardware sensors

are used in creating immersive experiences, particularly those involving cultural and artistic elements (Objective 1). John H. Falk and Lynn Dierking created the “Interactive Experience Model” in “The Museum Experience” in 1992. Since this experience exhibition, museums have started focusing research on how to improve museum experiences for the community (Falk, 2016). Kotler described the museum experience as immediate, emphasizing that it involves the audience directly, allowing them to understand relevant information through sensory stimulation (Kotler, 1999). Additionally, the museum experiences have been categorized by Professor Jixiang Shi into education, entertainment, aesthetics, and escapism based on the multidimensionality of experiences, noting that experiences involving multiple senses are the most memorable (Jin, 2020).

My research showed that many strategies use digital platforms, software, and hardware sensors in museum exhibition design. First, technology integration includes AR and VR, interactive technologies, sensor technology, AI, and mobile applications. Second, engaging narrative design through narrative and storytelling displays in the museum. Adopting narrative design enhances the attractiveness, educational value, and interactivity of museum exhibition design, which leads to meeting visitors' expectations and encouraging deeper engagement with the concept. Third, creating personalized experiences is very crucial in engaging diverse audiences. Museums can offer more targeted experiences through personalized content. For instance, offering personalized guided tours and creating interactive experiences using technologies such as touchscreens, gesture recognition, and motion sensors. In addition, multisensory experience is an effective method to build personalized content. By introducing visual,

auditory, tactile, olfactory, and gustatory elements, with attractive colors, lighting effects, sounds, aromas, etc., museums can stimulate visitors' perception and emotions, which provides visitors with a richer sensory experience (Huang, 2024).

The second step in this exhibition-based research was to investigate how Islamic geometric patterns have been incorporated into contemporary digital and tangible interactive designs (Objective 2). Two examples have been discussed in the previous section to illustrate how Islamic geometric patterns are preserved. *Sharjah Spectrum* by designer Zara Hussain (Figure 9) and *ZUHUR*, an interactive Islamic Art Experience by Haleem ul-Hassan (Figure 8), are two specific examples of how contemporary designers used traditional designs from Islamic geometric patterns to create an interactive exhibition that connects visitors to this tradition and culture.

The third step was to create an interactive digital and physical installation that combines software, hardware sensors, tangible woodcarving, and macrame threads to showcase traditional Arabic design elements in an immersive way (Objective 3).

Final Work

Handcrafted Installations

The final installation consisted of three physical pieces crafted from wood and macramé cords alongside a motion-activated digital display that responded to visitors' movements, creating a seamless interaction between the tangible and digital elements.

The physical work in the installation included the production of three pieces made with ¼ inch plywood that represent the three main categories of the Islamic geometric patterns attached to macrame pixel knots that illustrate Kufic geometric calligraphy design so visitors can interact by coming closer to see the patterns and the Kufic calligraphy. Macrame, made from natural fibers, such as cotton, provides a tactile, three-dimensional form that represents the handcrafted nature of Kufic Arabic calligraphy.

In addition to the hand-crafted wood that contains motives of the Islamic geometric patterns. These patterns are often associated with historical architecture and design known for their symmetry and repetition. Using natural materials, "wood and macrame cords," gives an opportunity to viewers to touch the geometric design to enhance their experience. Also, the technique of wood carving and knotting has been used across different cultures, especially in the Islamic world. This historical connection adds depth to this project because it combines artisanal traditions, wood curving, Kufic written by macramé cords, and Islamic geometric patterns in a contemporary interactive form with a digital connection.

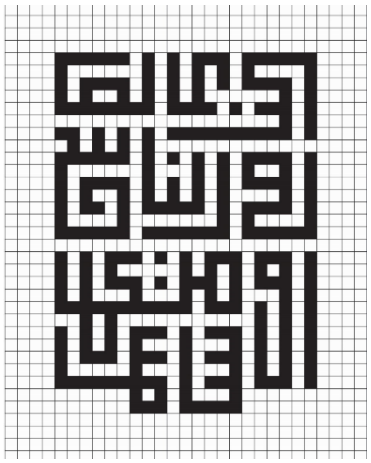
The written content on these macrame pieces is a poem that embodies the concept of engaging Arab culture with a diverse audience through interaction with its original art forms. The poem is “Be a Scholar Among People or a Learner” by Ibn al-Wardi. The macrame pieces inherited the first two sentences of the poem. He wrote: Be a scholar among people, or a learner, or a listener, for knowledge is a garment of pride. From every art, take, and do not be ignorant of it, for the free man is privy to secrets (Plate 1). In Arabic, it is:

قصيدة: كن عالما في الناس أو متعلما

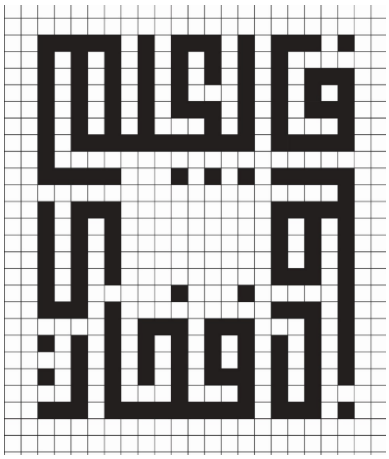
قال ابن الوردي: كنْ عالمًا في الناسِ أو متعلّمًا أو سامعًا فالعلمُ ثوبُ فخارِ

منْ كلِّ فنٍّ خذْ ولا تجهلْ بهِ فالحرُّ مطَّلعٌ على الأسرار

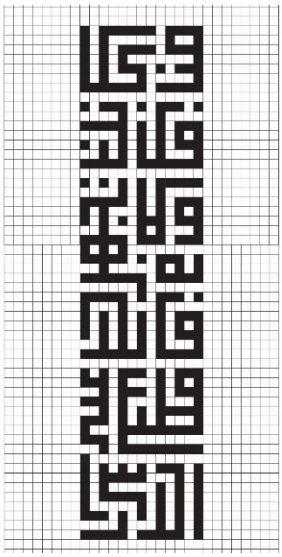
The choice of Ibn al-Wardi's poem is relevant to the concept of this project because he was a prominent Arab scholar, poet, and historian who was born in 1292. He was part of the Mamluk period, marked by cultural flourishing. His works highlight the importance of education, knowledge, wisdom, and values deeply embedded in Islamic intellectual traditions. Using his poem in my project reflects his lasting influence as a thinker who encouraged people to seek wisdom and understanding, which is the message that remains relevant in modern interactive designs that aim to engage and educate audiences.



Kufic script. English translation: Be a scholar among people, or a learner, or a listener,



Kufic script. English translation: for knowledge is a garment of pride.

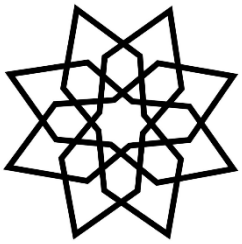


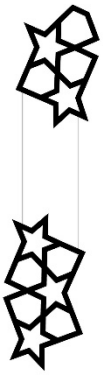
Kufic script. English translation: From every art, take, and do not be ignorant of it, for the free man is privy to secrets

Plate 1: *Kufic calligraphy designs for the Ibn al-Wardi poem "Be a Scholar Among People or a Learner*

The design elements of the Islamic geometric patterns on the wood sheets showed three basic techniques that are fundamental to hundreds of diverse geometric patterns. Eric Brough (2015) explains these three techniques, which started with a circle, and the differences between them rely on how many pieces to divide the circle. He stated that most patterns split the circle into four, five, or six equal sections, and each division gives rise to distinctive patterns. This number of sections on the circle determines whether any pattern is based on fourfold (Plate 2), fivefold (Plate 3), or sixfold (Plate 4). In addition, the grid of each pattern is essential to determine the scale

of the compositions and the complexity, keeps the pattern accurate, and facilitates the invention of unique elements in an incredible new pattern. Based on these fundamentals, this project implemented three patterns, one from each category.





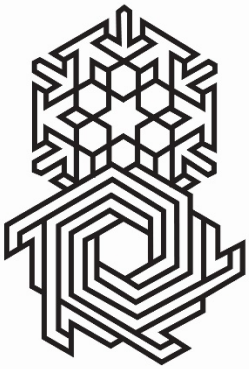


Plate 2: *Four-fold geometric wooden motives*

Plate 3: *Five-fold geometric wooden motives*

Plate 4: *Six-fold geometric wooden motives*

Interactive Projection:

The three installations interact with a digital sensory projection not only to create a dialogue between tradition and the modern interpretation of Arab culture but also to enhance visitor engagement. This interactive projection showcases various geometric patterns and colors that change in real-time based on visitor movement around the physical installations. Data is collected by ultrasonic sensors that measure the distance between visitors and the installations. As people approach wooden and macramé designs, the digital installation responds with changes in shape and color. This interaction symbolizes how tradition evolves when faced with fresh and modern perspectives.

The project uses a Raspberry Pi 5 to provide the flexibility needed for prolonged operation. Despite its small size, the Raspberry Pi 5 can control the sensors and run the visual script code efficiently (Plate 5). It features a 64-bit quad-core Arm Cortex-A76 processor running at 2.4GHz and an 800MHz Video Core VII GPU that supports dual 4Kp60 display output over HDMI.

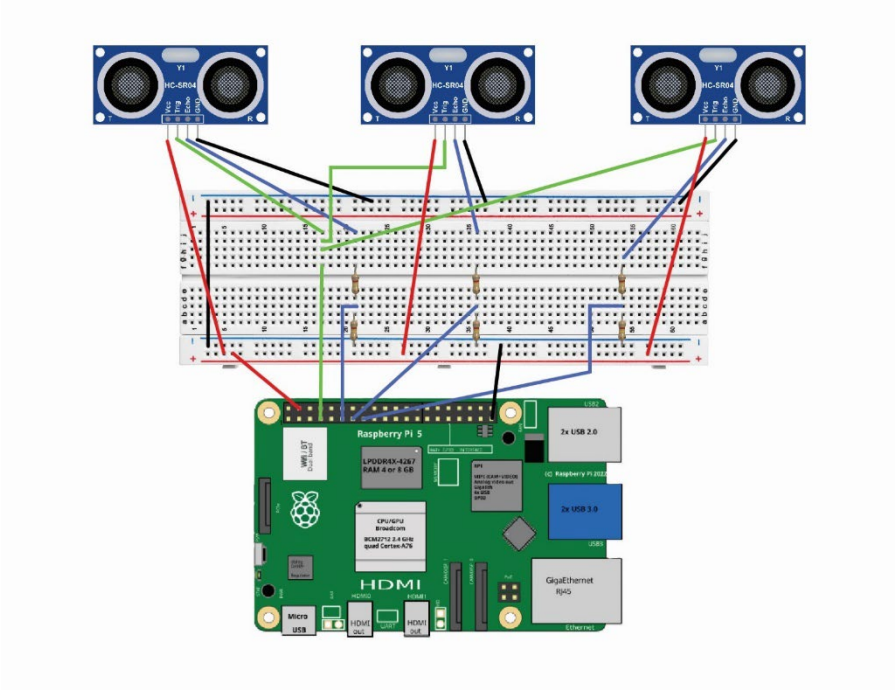


Plate 5: *Raspberry Pi 5 Connecting to Three Ultrasonic Sensors*

The project also employs three HC-SR04 ultrasonic distance sensors, which offer non-contact measurement functionality from 2cm to 400cm with an accuracy of up to 3mm. Each sensor includes an ultrasonic transmitter, receiver, and control circuit. The HC-SR04 connects to the Raspberry Pi through four pins: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground), (Plate 5). A short-throw projector was chosen to enable projection onto the exhibition wall from a short distance.

Visual Studio was the software used to run the p5.js library for JavaScript. P5.js is a user-friendly tool for learning to code and creating art; it is an open-source JavaScript library developed by a creative community. P5.js welcomes designers, artists, educators, and others to build and explore projects with endless possibilities. This library emphasizes accessibility, inclusivity, community, and creativity, making it as

intuitive as sketching in a notebook. It supports audio-visual, interactive, and experimental projects for the web and is well-documented with visual examples.

This project draws inspiration from educator and creative coder Daniel Shiffman, who created an Islamic star pattern using p5.js on his website The Coding Train. Shiffman explains the logic behind building interactive geometric patterns by manipulating anchor points. Through his tutorials, I learned how to construct the base structure of patterns and then applied these techniques to create more complex, morphing designs. I connected the p5.js code with a Python 3 script to process sensor distance data. The pattern colors are dynamically adjusted based on data from the three sensors, with each sensor influencing one color—blue, green, or red—to produce varied colored patterns. The final visual output is hosted on an offline web editor, allowing the project to run without an internet connection.

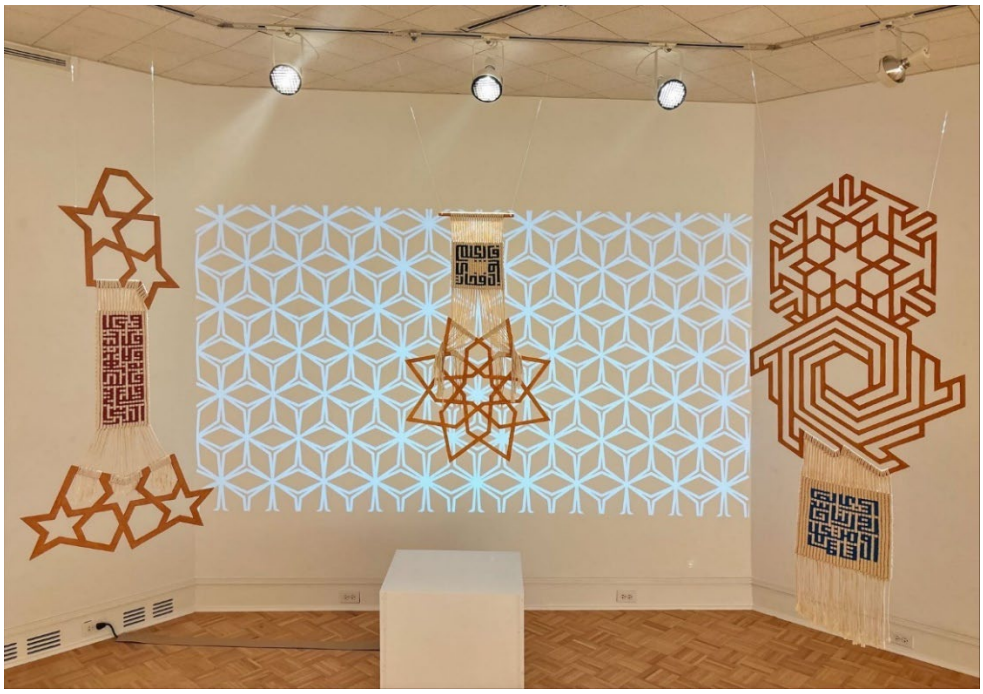
Audio

Additionally, this interactive exhibition featured background music performed on the oud, an instrument that originated in ancient Egypt. Known as the "king of instruments" in Arab countries, the oud holds a significant place in traditional Arab music. The featured piece, “Flower Madeo,” was composed by a Japanese musician named Sogabe. He explained that his goal was to create traditional music with a modern, contemporary twist, blending historical music notes with his unique, modern perspective. Sogabe also noted that the oud is played differently across Arab countries, and his style involves combining notes from various traditions to craft new, immersive compositions. The inclusion of his music added depth to the interactive exhibition,

allowing it to resonate with visitors' auditory senses and create an immersive experience of Arab culture.

Exhibition Space

The interactive exhibition, which combines the three physical installations and the interactive projection with a station housing the Raspberry Pi and sensors, was held at the Gray Gallery at the School of Art and Design. It opened on the same day as the Downtown Greenville ArtWalk, attracting many visitors from diverse backgrounds and cultures. This turnout was essential for achieving the exhibition's goal of engaging a diverse audience with Arab culture (Plate 6, 7, 8).



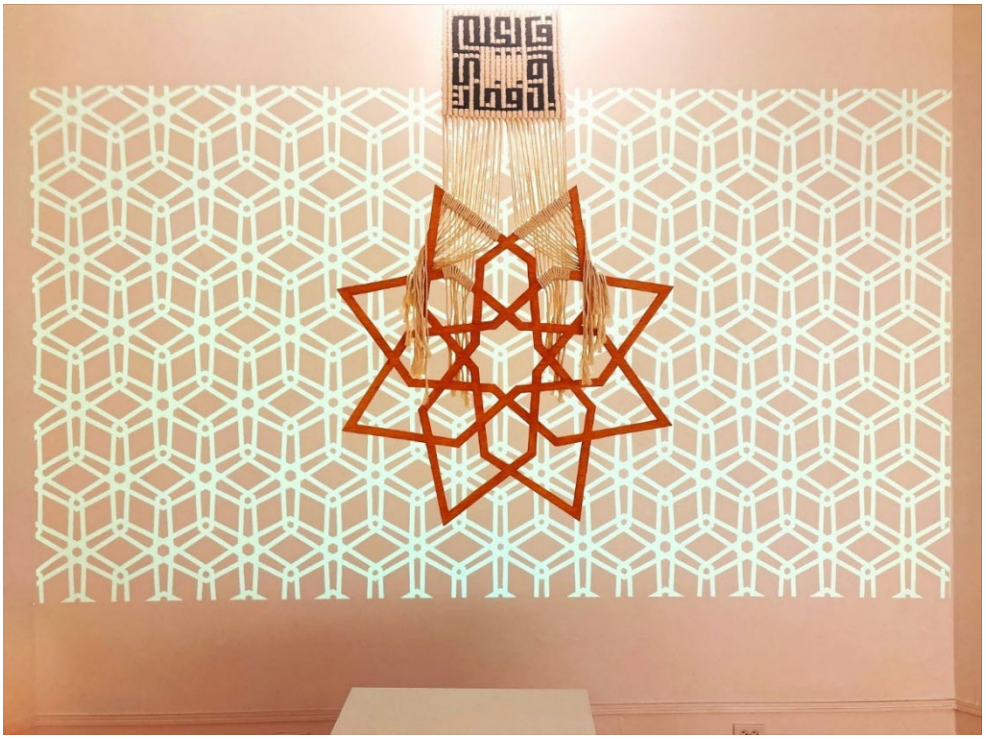
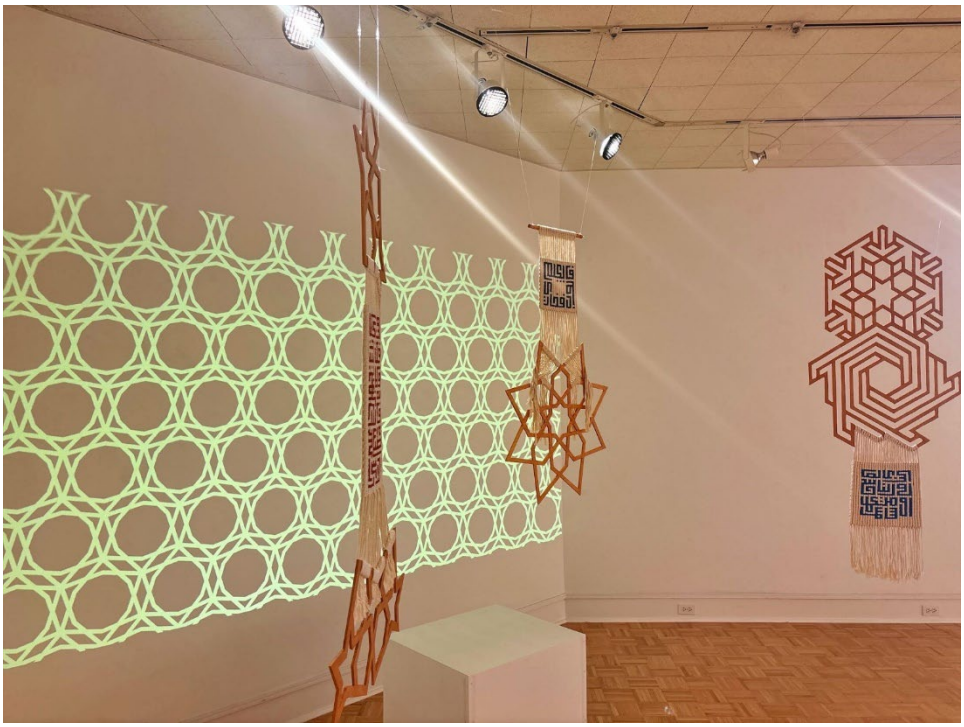


Plate 6: *The Interactive Exhibition - Front Shot*



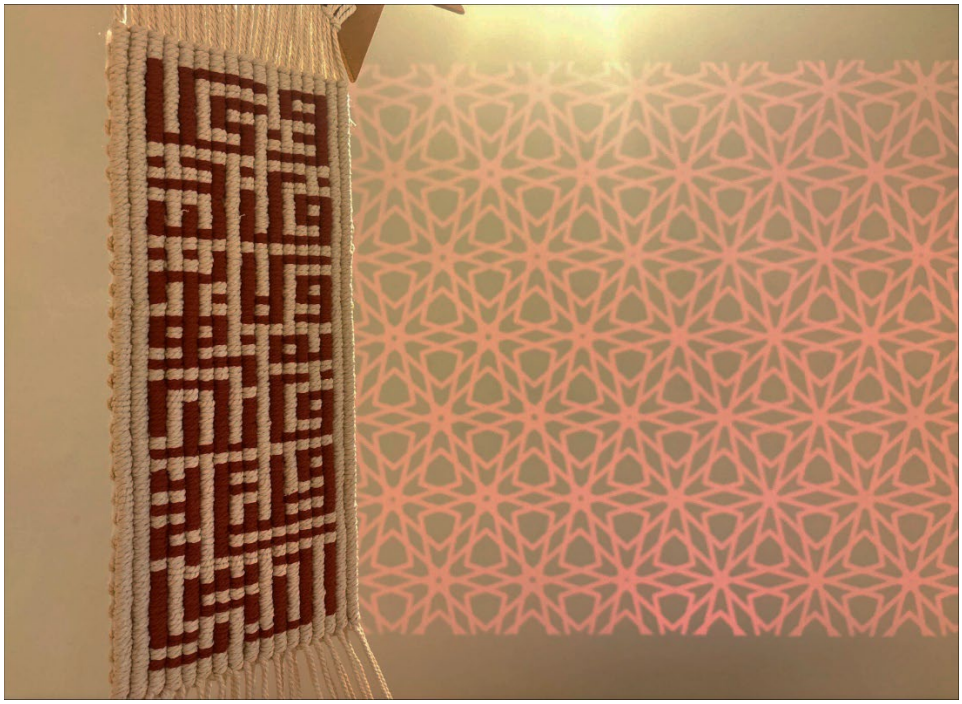


Plate 7: *The Interactive Exhibition - Left Side Shot*

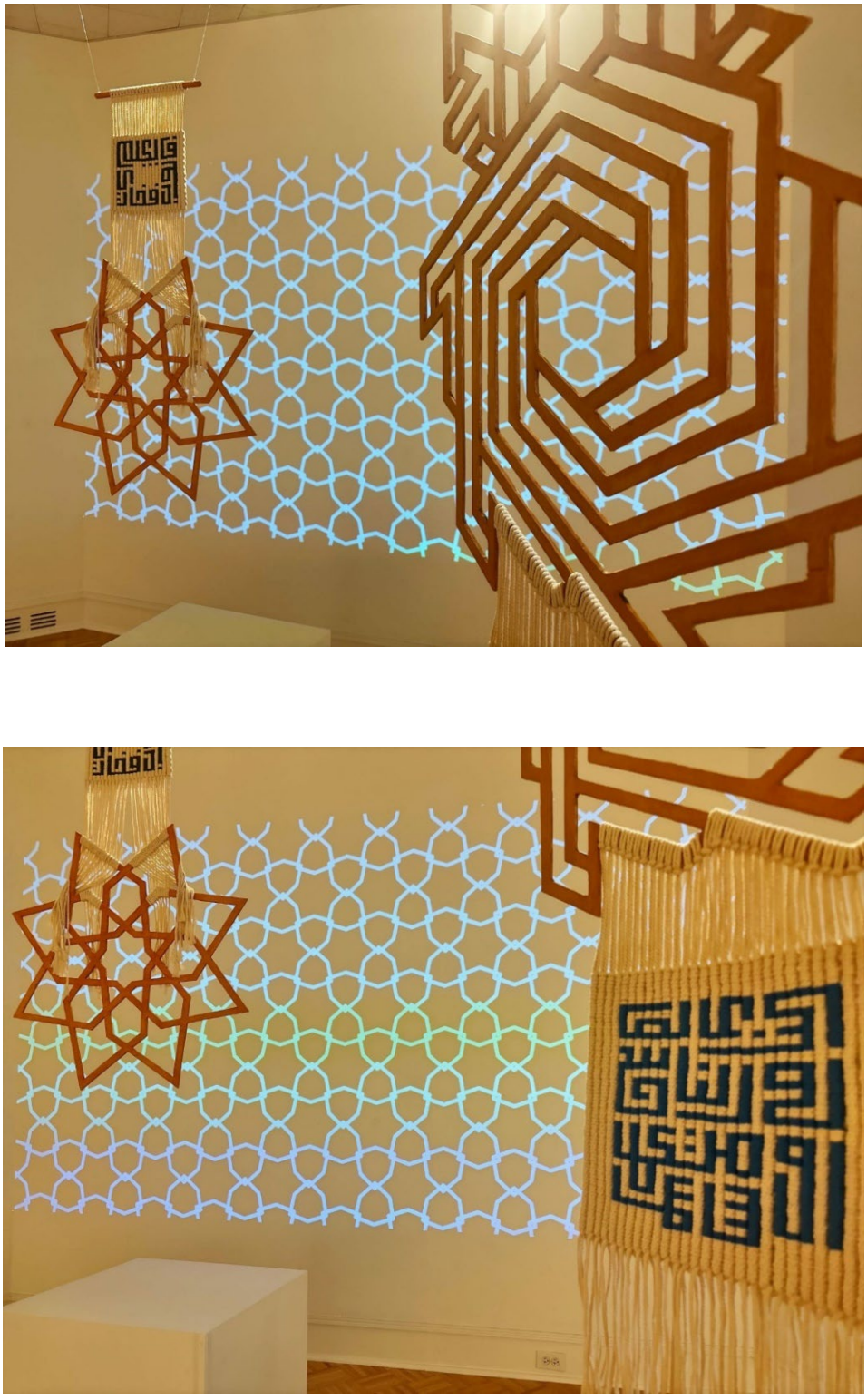


Plate 8: *The Interactive Exhibition - Right Side Shot*

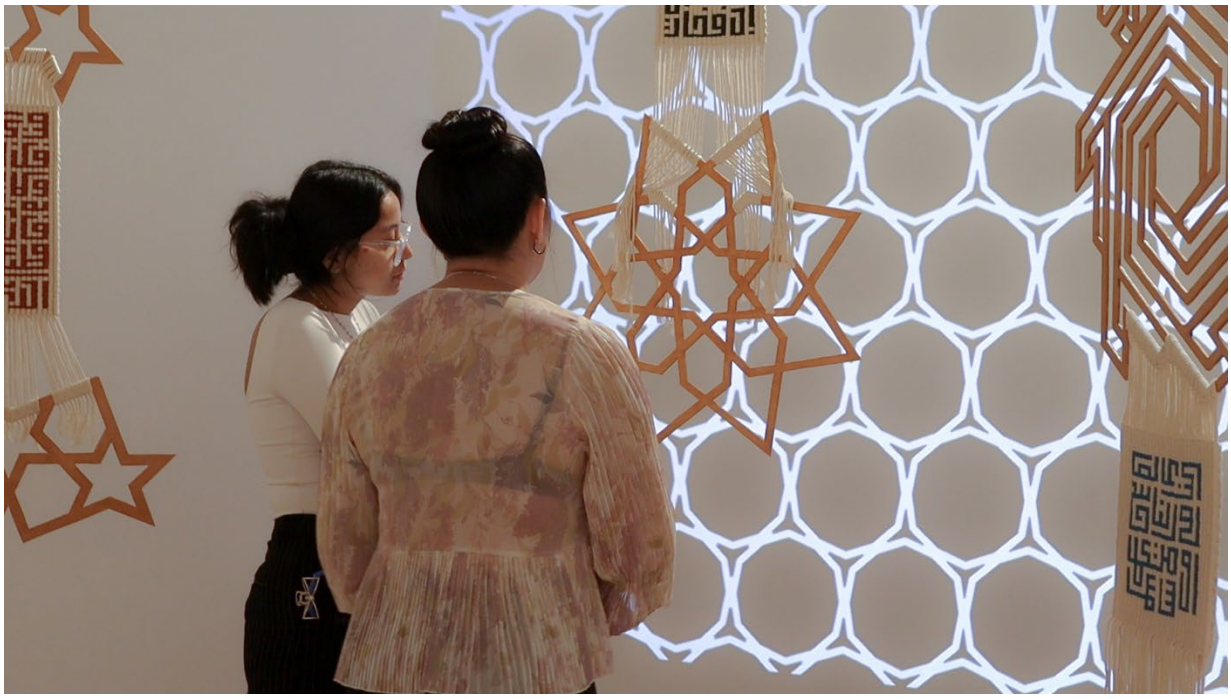
Results:

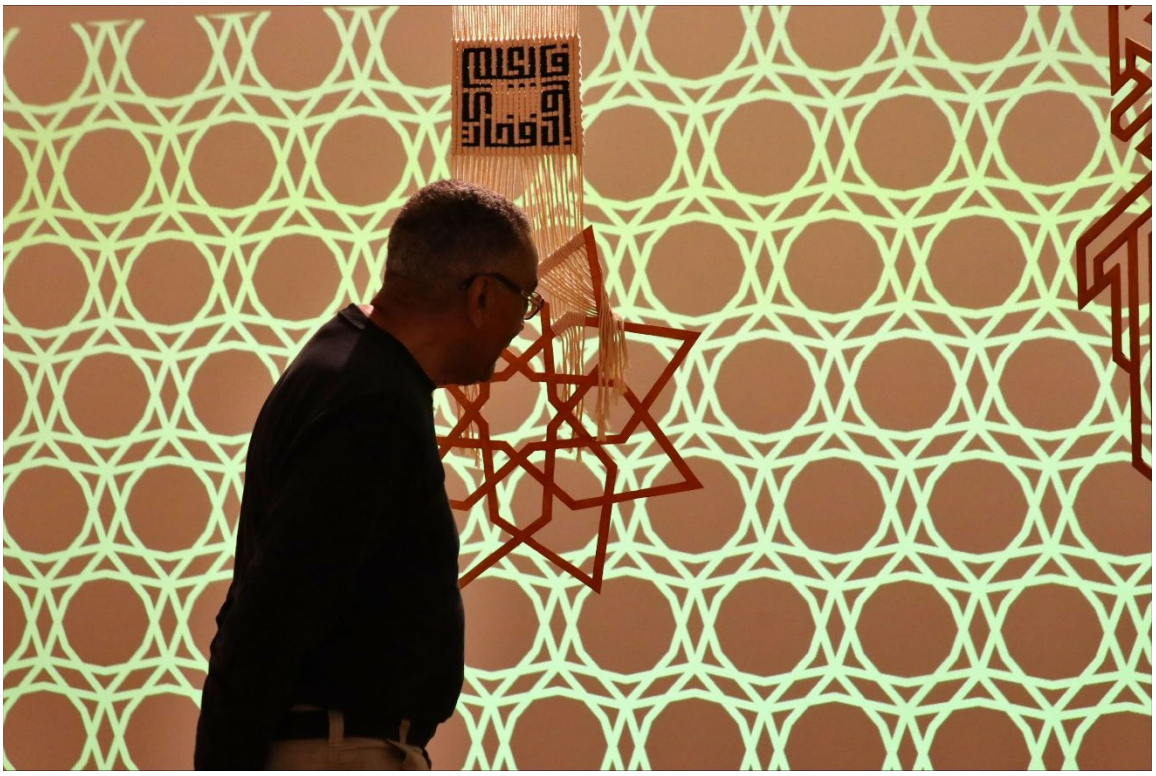
Two primary methods were used to evaluate the success of this interactive exhibition: observation and direct conversations. Observations were conducted over the course of two hours during the exhibition opening, focusing on how visitors interacted with both the physical and digital installations (Plate 9). I closely monitored their behaviors, noting moments of engagement, curiosity, and reactions to the changing visual patterns and colors projected on the wall.

Additionally, I engaged in direct conversations with more than 20 visitors, each lasting a few minutes. These discussions provided qualitative feedback on their experiences, impressions of the installations, and engagement with Arab culture through the exhibition.

Analysis of Outcomes

Observations reflected that visitors were intrigued as they approached the physical installations made of wood and macramé, often reacting positively to the responsive digital patterns. One of the visitors' comments that I received during the discussion was that "this combination successfully drew attention to the cultural significance of Arab and Islamic designs." Both verbal and non-verbal feedback, such as smiles, comments, and extended interactions, underscored the effectiveness of blending tactile and digital media to create immersive experiences that engage Arab culture.





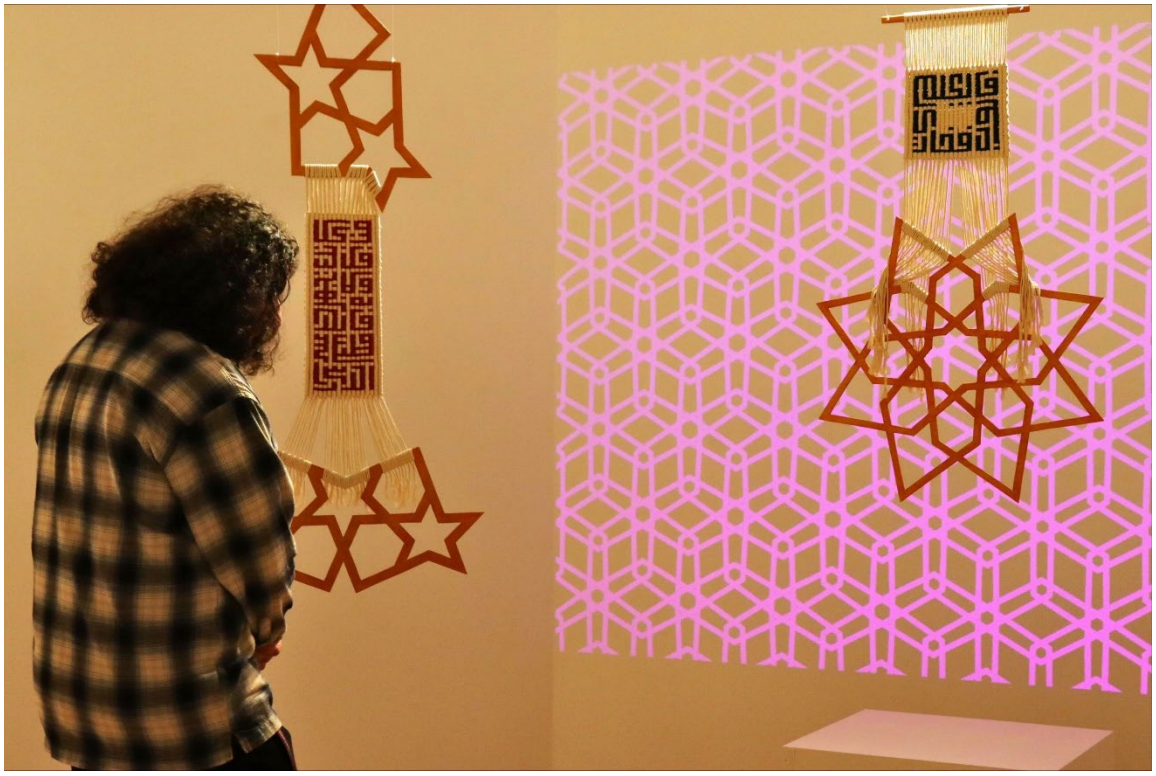


Plate 9: *Visitors' Interactive Experiences in the Exhibition Space*

Future Work

Using traditional elements of Islamic and Arabic designs and presenting them in a contemporary interactive exhibition is an effective way to showcase Arabic culture and designs. It also fosters greater participation and engagement from a diverse and open-minded audience.

This interactive exhibition has inspired me to explore new, modern approaches to create deeper interaction between graphic design and the viewer. In the future, I plan to develop experiences that engage all human senses and stimulate curiosity. This could include integrating electronic sensors into the artwork to create a fully immersive, interactive experience. Additionally, I am passionate about promoting Arabic culture and learning about other cultures. I aim to create interactive designs that merge various art forms and cultural elements to bridge gaps between people and foster understanding. In my future work, I aim to deepen my knowledge of different cultures and create a mature, artistic dialogue that celebrates and connects our differences.

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