

Developing Kufi Haptic Prototype for Visually Impaired People

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ABSTRACT

Visual art is often inaccessible to people with visual impairments. This group should not be overlooked as demands for equality in human rights grow. This study explores the development of a Kufi haptic prototype to support lifelong learning for visually impaired individuals in the context of Islamic art, culture, and heritage. Guided by practice-led research and inclusive design principles, the development of Kufi haptic prototype integrated insight from kufi practitioner and representatives of the visually impaired community. The findings contributed to the fundamental process of interpreting traditional Kufi letterform into an accessible form for visually impaired people's application and the development of an assistive tool, namely the prototype which consists of a 2.5D Kufi Tactile Guide Card and Tactile Grid Base. This study highlighted the importance of collaborative process with multiple stakeholders, theoretical and technical aspects in Kufi haptic prototyping to generate a practical haptic tools. The tools will allow visually impaired people to access Arabic script in tactile form beyond the limitations of traditional Arabic Braille. These approaches enhance the opportunities for knowledge transfer into creative skills that ultimately support human capital development in a knowledge-based society.

Keywords: Design Education, Inclusive Design, Islamic Art and Heritage, Tactile, User-Centered Design

INTRODUCTION

Kufi is known as the earliest Islamic calligraphy. It is a form of visual art that utilizes the Arabic script. Today, kufi calligraphy is gaining a potential market within the community. The application of kufi calligraphy is not limited to documenting the verse of the Quran but also include commercial purposes such as logo design, signage, sculpture, graphics, interior design and architectural ornamentation (Abdul Halim et al., 2011; Alashari et al., 2020; Hussin et al., 2017). Interestingly, Ramli et al. (2021) also identified that Islamic art is potentially able to create job and business opportunities and, hence, generate a source of income. Despite that, for individuals with vision impairment, appreciating

visual art can pose challenges, leading to missed opportunities. This argument has been supported by Cavazos Quero et al. (2021). In Malaysia, visual art is usually more accessible to the sighted people, yet it is very limited for the non-sighted people to appreciate.

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Examining the literature context, the discussion on accessibility of visually impaired people towards Arabic lettering is often limited to the use of Arabic Braille (Fatimah Nazihah et al., 2016; Mohd Noor & Mujani, 2016; Omar et al., 2019). Even though the current research unarguably supports the significance of Braille to visually impaired people, the drawback of this media is that it does not communicate the original form of the letter. Notably, Braille uses raised dot cells, while Arabic, lettering such as Kufi script, relies on geometric forms. Given the wide applications of Islamic calligraphy, this mismatch may limit visually impaired individuals from gaining equal opportunities to learn skills beyond basic reading. The raised concerns on inclusive learning opportunities within this minority group are highlighted locally in Malaysia and globally through the Sustainable Development Goals 2030 by the United Nations. Therefore, innovative designs that open up opportunities for the visually impaired people, to be part of the mainstream society are in demand. The above statement was highlighted by the community at the 2021 Malaysian Visually Impaired Development Affairs Round Table Conference.

Sensory substitution, especially haptic sensation through tactile design, is one of the most highlighted methods to overcome accessibility in relation to visual limitation among non-sighted people. This approach has been outlined by previous authors such as Candlin (2003), Onol (2011), Argyropoulos and Kanari (2015), Gravern et al. (2020b), Lloyd-Esenkaya et al. (2020), and Cavazos Quero et al. (2021). The findings indicated that tactile or ‘touch’ is a natural way of navigation by visually impaired people. The approach’s effectiveness requires an in-depth understanding of how the tactile information is encoded, transferred, and processed at all phases during tactile interaction. This argument has also been emphasized by Pasquero (2006, as cited in Tala, 2016).

In the context of Islamic calligraphy, it is undeniable that the tactile version exists physically. Nevertheless, there has been minimal investigation of the literature thus far that truly elucidates how haptic Islamic calligraphy can be designed to cater to the needs of non-sighted individuals and how they can appreciate this Arabic lettering within the context of Islamic art value. Therefore, the research is significant as it examines how the three keywords, “kufi calligraphy,” “haptic,” and “visually impaired people,” are being integrated and enhance the body of knowledge and practice, especially in the inclusive Islamic art and heritage. The objective of this paper is to outline the fundamental process of interpreting traditional kufi letterforms into accessible forms for visually impaired people application. The development of the kufi haptic prototype typically follows an iterative prototyping procedure. This paper focuses on the preliminary stage; from conceptualisation to tangible prototype proposal; while reserving the evaluation of the prototype for future research.

METHODOLOGY

The roles of prototyping include enabling communication, informing decision-making, and aiding in learning (Lauff et al., 2017). Previous scholars have highlighted that elements such as form, size, object dimensions (2D/2.5D/3D), and material properties are among the key factors discussed in tactile prototyping, particularly in contexts involving visually impaired individuals (Cavazos Quero et al., 2021; Onol, 2011; Wilson et al., 2020). Additionally, early collaboration between designers and end-users is also crucial in determining the usability of a prototype (Braille Authority of North America, 2010). Guided by these considerations, the current study aims to connect Kufi forms with visually impaired people through haptic prototyping exploration.

Participant

Guided by practice-led research and inclusive design principles, this research was shaped by contributions from key stakeholders including a Kufi practitioner (n = 1) from Persatuan Kufi Khat Murabba' known as Friends of Kufi Square (FoKS) and representatives (n = 2) from Malaysian Association for the Blind (MAB). This research employed kufi calligraphy from FoKS Discipline based on its established ruling in square kufi writing and recommendation from the National Islamic Calligraphy Art Association of Malaysia. The research invited the developer of the FoKS Discipline, who is an expert in FoKS Discipline and also an active kufi calligrapher, to represent the practitioner role.

In addition, the research incorporated perspectives from the representatives of research and development department of MAB, including one member who is visually impaired. While FoKS's practitioner contributed expertise on the structural rules of Kufi script, the MAB representatives provided insights into the needs of visually impaired people, particularly on tactile design and accessibility requirements.

Instrument and Procedure

The development of the kufi haptic prototype involved both fieldwork and studio activities. In line with Macdonald (2012), the current research employed multiple types of data collection methods, including in-depth interviews, document (FoKS Kufi chart), and creative practice (prototyping). The research began with online interviews with both parties to identify the fundamental concepts of Kufi calligraphy and the design requirements related to visually impaired people. The semi-structured interviews were recorded, transcribed and analysed before proceeding to the design experiment stage at creative practice.

The creative practice involved adapting the concept kufi calligraphy into a tangible Kufi haptic tool. Data gathered from the interview sessions and document (FoKS Kufi chart) were intergrated as guidance during design experiments. The research explored varies tactile qualities and sizes to learn, adapt, and improve the prototype. The design processes were documented through photographic and video records. The outcome of this exercise is identified as Prototype 1. Table 1 presents a summary of research procedure and its evaluation purposes.

Table 1
Summary of research procedure and evaluation purposes

Procedure	Exploratory Tool/Analytical Approach	Evaluation Purpose
<i>Step 1: Data Collection</i> Conducted a semi-structured interview with kufi partitioner and representatives of Malaysia Association for the Blind (MAB).	Semi-structured interview (online), FoKS Kufi chart (recommended from FoKS)	Identify the fundamental concept of kufi calligraphy (from FoKS) and design requirements related to visually impaired people (from MAB)
<i>Step 2: Data Analysis</i> Data transcription, interpretation, & organization	Thematic analysis	To generate key themes of kufi haptic design requirement
<i>Step 3: Creative Practice (Prototype Development)</i> Development of Prototype 1 based on key themes gathered from Step 2.	Design experiment (Testing materials with different tactile qualities and sizes to learn, adapt and improve the prototype)	Adapting the concept Kufi haptic into a tangible Kufi haptic tool.

Data Analysis

Data gathering was based on a qualitative approach in relation to the prototyping design procedure. Thematic analysis and data triangulation were applied to the interview and document data, hence, generating key themes of kufi haptic design requirement (Figure 1). The process of reading, creating codes, organizing information, transcribing, interpreting, and translating data was done manually based on human skills. However, this study used *ATLAS.ti* software as assistance in managing, sorting, and merging the data, as well as some other software such AutoCAD and Adobe Photoshop to support the visual illustration part.

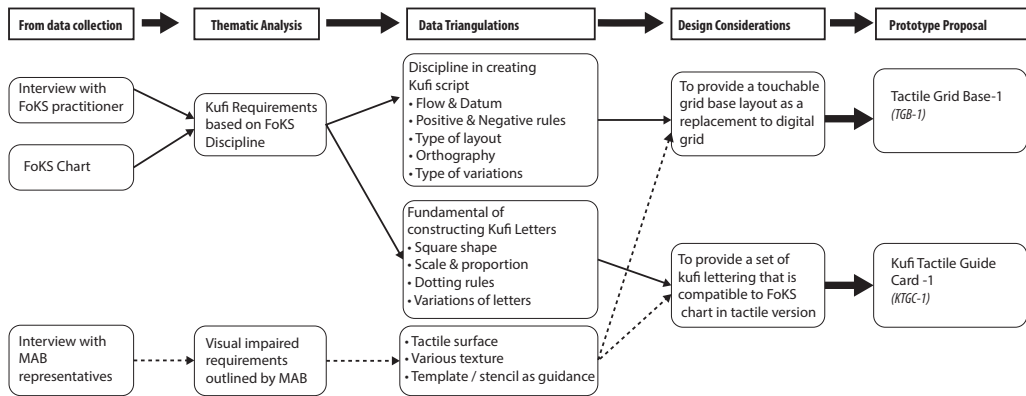


Figure 1. Flow of data analysis and prototype development (Source: Author, 2024)

RESULTS AND DISCUSSION

Adaptation of FoKS Discipline into the Non-Sighted Context

This section presents the results from the initial stage of the prototyping process, which focused on translating requirements into preliminary design considerations and prototype proposals. The study found that there are variations of the Kufi letterform depending on where it is being applied in a sentence and mastering square kufi calligraphy usually requires several stages of learning. However, this study focused only on the fundamental process of interpreting the basic Kufi letterform, which is the ‘isolation type’. Methodologically, it takes three major steps to convert traditional Kufi into multisensory Kufi haptic prototypes, as described in Figure 2. Detail discussion will be presented through a retrospective of the creative practice of proposed prototypes as follows:

- i. Building a Kufi Tactile Guide Card 1 (KTGC-1)
- ii. Developing Tactile Grid Base Layout 1(TGB-1)

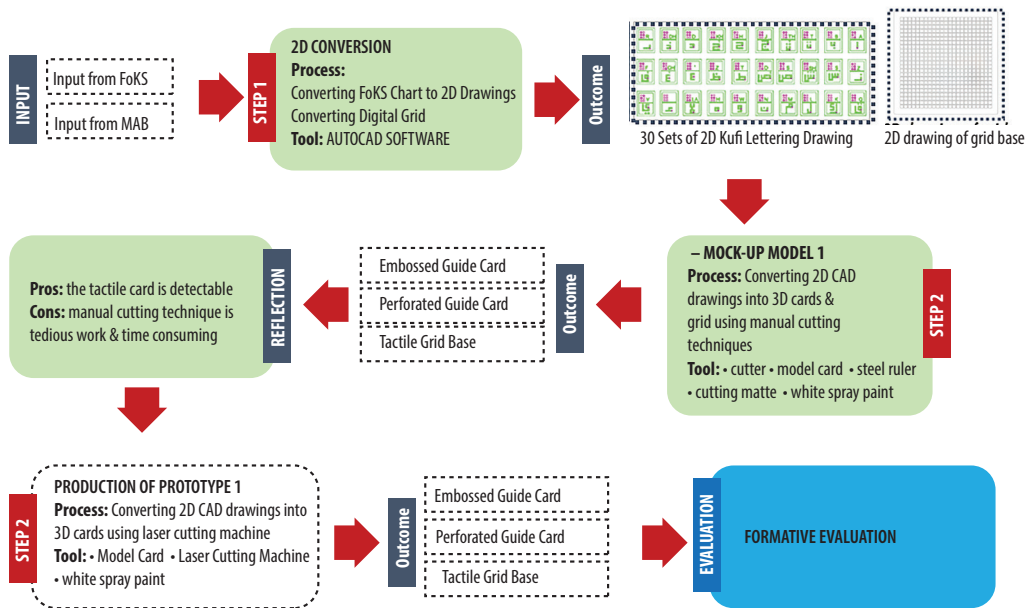


Figure 2. Fundamental of prototyping procedure of prototype 1- Kufi haptic design (Source: Author,2024)

Building a Kufi Tactile Guide Card (KTGC-1)

KTGC-1 refers to the first generation of kufi tactile guide cards. KTGC-1 was developed by intergrating the principles in FoKS chart with tactile requirements of visually impaired individuals as outlined by MAB. The FoKS chart consists of Two-Dimensional (2D) square kufi lettering that illustrates the fundamental rules of the FoKS discipline for constructing a square kufi letterform. It has been used as a reference by sighted individuals, especially beginners, in learning and producing square kufi illustrations.

There were three steps involved in creating the card. The first step was translating the 2D letterform from the FoKS chart using Computer-Aided Design (CAD) software. The software offers flexibility including easy modification, direct modelling with precise duplication of drawings and compatibility with various file formats to meet the requirement of both the ideation stage and for printing purposes. The researcher had drawn 30 types of kufi letterform for the first prototyping stage. Preparation of Mock-up 1 in Step 2 was carried out manually. Two types of mock-ups were prepared: embossed KTGC-1 and perforated KTGC-1. The thickness of the embossed/perforated surface was set out at 1mm thick based on the suggestion of a detectable Braille dots in a printed document highlighted in Braille Authority of North America (BANA).

Step 3 followed the previous procedures except that the final production of KTGC-1 employed a laser cutting machine to improve efficiency and cutting accuracy. Each card contains three main components: Braille dots, Latin/Rumi script, and segmented kufi letterform. All CAD drawings were converted from .dwg to .dxf format to be operated at

the TROCEN application. Upon completion, a white matte paint finish was applied to the KTGC-1 and a velcro textured surface (hook type) was added to the selected tiles of the kufi letterform. Figure 3 summarizes the prototyping process of KTGC-1.

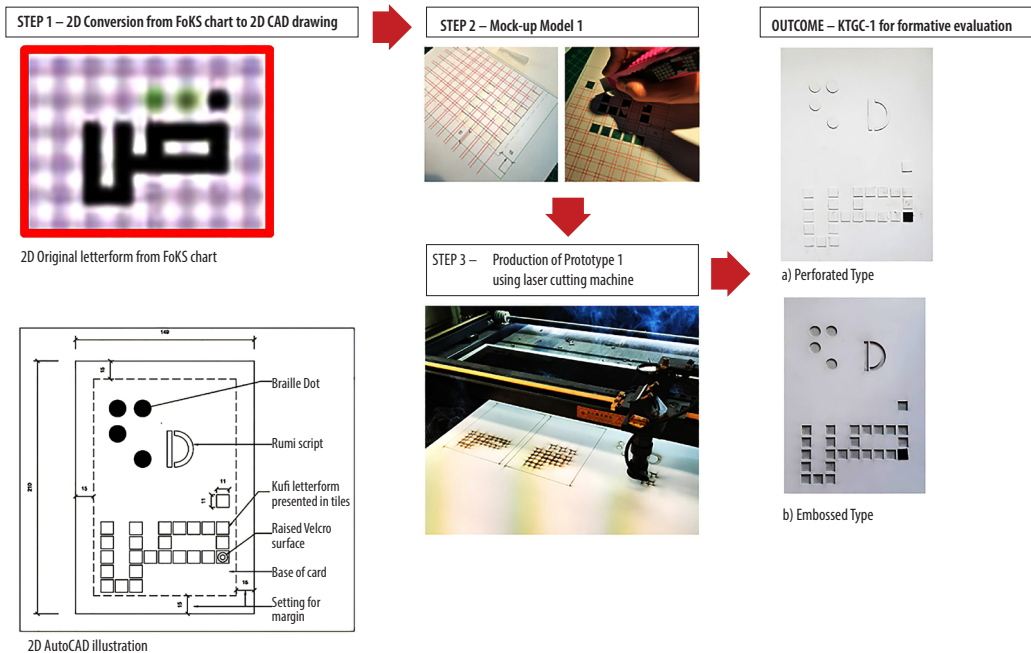


Figure 3. Prototyping process of KTGC-1 at creative practice (Source: Author, 2024)

Developing Tactile Grid Base Layout (TGB-1)

Based on FoKS, the beginner (sighted people) relies on a digital grid to control the scale and proportion of the kufi letterform. Unfortunately, visually impaired users have limited access to this technology, hence, the research propose a physical grid as an alternative. To begin with, this study required an understanding of FoKS’s five principles in creating the kufi script to assist the researcher in planning the grid layout. These are ‘Flow and Datum’, ‘Positive and Negative Rules’, ‘Type of Layout’, ‘Orthography’, and ‘Type of Variations’, as described in Figure 4.

Based on the calculation, a 23 x 23 grid (529 boxes) is required to enable all ‘isolation type’ of kufi letters to rotate and fit into the grid base. The researcher also had to consider the maximum board size that could be fitted into the available laser-cutting machine. The study reported that the total size of the grid base was influenced by the individual grid size. In addition, the scale of the grid base is also required to withstand the ergonomic and anthropometric requirements for the work surface. For this reason, the research used Malaysia Standard MS1184:2014 Universal Design and Accessibility in the Built Environment Code of Practice as a reference. The overall grid base size for Prototype 1

was established at 490 mm x 490 mm, fitting neatly within the dimensions of an A1 board and adhering to the specifications outlined in the code of practice. The grid was designed with a 3mm gap between the tiles. Four areas marked as textured surfaces, known as the ‘home key’, which were designed to indicate the turning point for each kufi letter. The research employed a similar production process to those of KTGC-1. The CAD illustration of TGB-1 of Prototype 1 is presented in Figure 5.

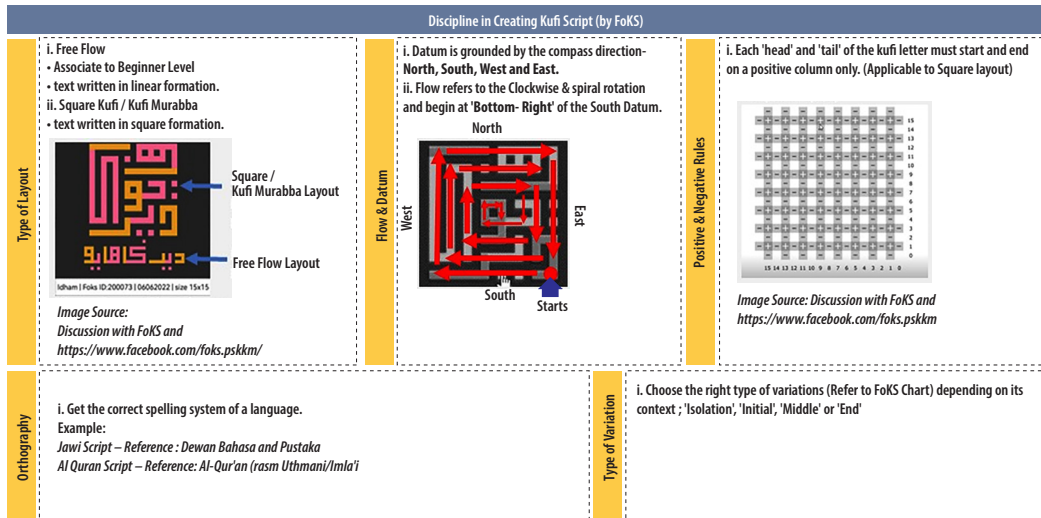


Figure 4. FoKS discipline in creating Kufi (Source: Author, 2024)

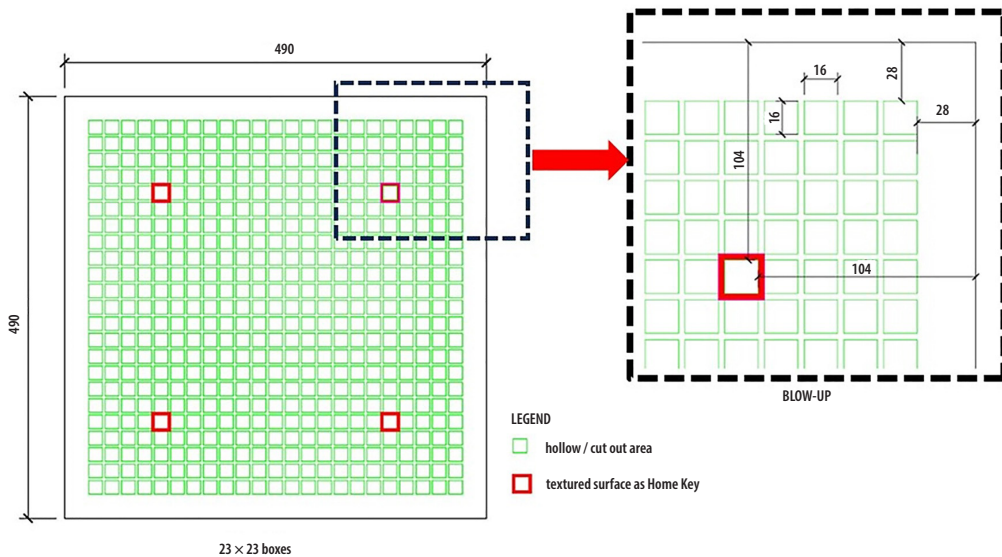


Figure 5. Tactile Grid Base (TGB-1) in 2D Computer-Aided Design (CAD) drawing (Source: Author, 2024)

Comparison between FoKS Discipline and Prototype 1

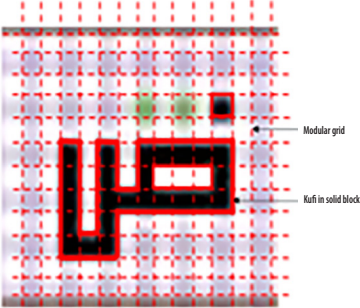
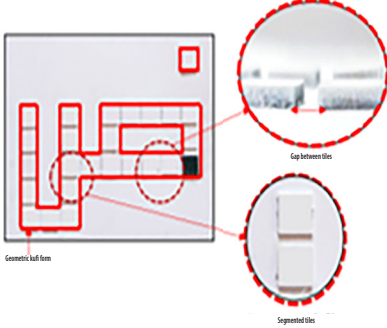

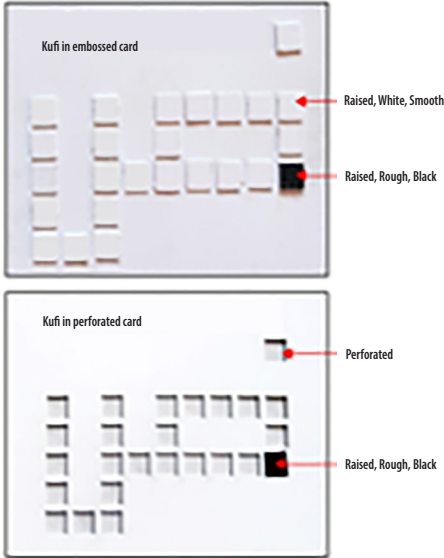
Technically, Kufi design in FoKS discipline and Prototype 1 adopt grid modular system and counting techniques to structure the Kufi letterform. The flow of reading is from right to left which is the common way of reading the Jawi/Arabic script. However, as described in Table 2, several modifications were applied to Prototype1 to incorporate the design requirements of visually impaired users. These adaptations demonstrate how traditional kufi design principles can be reinterpreted to allow accessibility of visually impaired people in visual art.

Several adjustments were also introduced towards visual aspects of haptic kufi letterform (KTGC-1) compared with the FoKS chart to improve letter clarity, as described in Table 3. While both concepts embrace geometric and square/block-like form, the KTGC-1 was intentionally designed with additional gaps in between its repetitive segmenting blocks and the base (either raised or perforated), to enhance participant’s tactile experience. Visual contrast in KTGC-1 was also achieved through the use of colour and surface variation between the general tiles and the ‘home key’ tile. These design elements were incorporated into KTGC-1 to improve tactile feedback, especially on the ‘home key’ tile. In contrast, Kufi letterform in FoKS appear smooth and flat with visual contrast defined by horizontal and vertical strokes, as well as the use of negative space. Both types of Kufi rely on block/tile count and modular grid to control scale and proportion.

Table 2
Comparison between FoKS Discipline and Prototype 1

Similarities / Differences	FoKS Discipline	Prototype 1
Similarities	Letterforms are all geometric, modular and segmented	Letterforms are all geometric, modular and segmented
	Use modular grid as guide	Use modular grid as guide
	Flow of reading – right to left	Flow of reading – right to left
Differences	<i>FoKS Chart:</i> Tabulation of kufi letters is presented in one schedule	<i>KTGC-1:</i> Individual Kufi letter per card to avoid excessive information in one card.
	<i>FoKS Chart:</i> Display all types of Kufi variations in one schedule (i.e.; isolation, initial, middle, end)	<i>KTGC-1:</i> Focus on “isolation” type to avoid excessive information and support basic learning.
	<i>FoKS Chart:</i> Digital schedule	<i>KTGC-1:</i> Hardcopy/Tangible tactile card
	<i>FoKS Chart:</i> Display only Kufi Letters	<i>KTGC-1:</i> Incorporate Jawi/Arabic Braille Dots & Rumi script
	<i>FoKS Grid Base:</i> Digital grid	<i>TGB-1:</i> raised grid system with ‘home key’ indicator and spatial ratios, detectable through finger tracing to ensure consistent letter shapes and alignment.

Table 3
 Comparison of original Kufi Letterform and Kufi Haptic Letterform

Kufi letterform from FoKS Chart (Isolation Type)	Kufi haptic letterform (KTGC-1)
<p>Geometric, square/block-like form. Built from separate blocks; appears as one unified form when complete.</p> 	<p>Geometric, square/block-like form and segmented. Repetitive tactile segments with visible gaps between each tile.</p> 
<p>Contrast through vertical and horizontal strokes and negative space. Smooth and flat visual surface.</p> 	<p>Contrast through surface variation: raised/perforated, smooth/rough and colour (white general tile/black for 'home key')</p> 
<p>Movement of eye guided by horizontal/vertical strokes</p>	<p>Touch guided by block-to-block connection</p>
<p>Scale and proportion adjusted based on block count and modular grid</p>	<p>Scale and proportion adjusted based on tile count, and modular grids</p>

The study also shows that, although the development of Prototype 1 focused on modifications for accessibility, the basic visual construction principles remain aligned with the cultural significance of Kufi design, including the use of square blocks and the consideration of horizontal and vertical strokes in letter formation. According to Kaddour (2021), within the context of Islamic culture, the interplay of horizontal and vertical strokes in Kufi forms reflects sacred duality, symbolizing a spiritual connection between heaven and earth. In addition, the presence of a tactile grid base in Prototype 1 with geometric and modular characteristics functions as a strategy to structure Kufi letters systematically while maintaining scale and proportion in the artwork. These design features correspond with previous studies, which emphasize that the geometric arrangement of letters, translated through mathematical precision, contributes to compositions that reflect cosmic harmony, spiritual rhythm, and divine order (Abdul Rahim & Hamidon, 2022; Kaddour, 2021; Sakkal, 2003). This indicates that while the primary objective of Prototype 1 is accessibility, its foundation may also enable visually impaired users to later explore the aesthetic and semiotic dimensions of Kufi in their creative practices.

CONCLUSION

This research concludes that translating traditional Kufi into haptic form for visually impaired users requires collaborative input from multiple stakeholders and technical innovation. The developed prototypes (KTGC-1 and TGB-1) demonstrate the potential to bridge the Islamic heritage and visually impaired community in an inclusive way. However, as the current study is limited to the initial stage of haptic prototyping, its findings should be viewed as exploratory rather than conclusive. Future research will further investigate the usability and effectiveness of the prototypes as an assistive tools for visually impaired people's engagement with Kufi calligraphy. Looking forward, this research may create more opportunities for visually impaired community to participate in creative industry, particularly within Islamic art and heritage.

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