Exploring NFC Technology's Driven Graphic Design Within an Educational Setting

Rohaida Razi*
Politeknik Ibrahim Sultan, Pasir Gudang, Masai
Johor Bahru, Malaysia
Corresponding author
Email: rohaidarazi.pis@gmail.com

Normatul Shafinaz Omar*
Politeknik Ibrahim Sultan, Pasir Gudang, Masai
Johor Bahru, Malaysia
Email: normatul@pis.edu.my

Received Date: **18.11.2023**; Accepted Date: **05.02.2024**; Available Online: **31.03.2024**

**These authors contributed equally to this study*

ABSTRACT

There is limited information regarding market trends for Near Field Communication integration in graphic design for 2024, but there are numerous trends and projections for the visual communication industry and related industries. These trends include the growth of the markets for visual content and visible light communication, the dominance of video content in digital marketing strategies, the rise of 3D designs, and the continued importance of print media in visual communication. Therefore, implementation of NFC technology is viewed as an emerging trend that can be incorporated in several ways into graphic design to improve the user experience and generate more engaging and personalised experiences in phygital (physical and digital) world. This study explores the potential of this technology in an educational context for graphic design. Due to the insufficiency of research in the field, this study seeks to provide a preliminary overview of NFC technology and the technology beneath it that will be beneficial to the field. The qualitative approach is used to determine the capabilities, potential benefits, and applicability of NFC in related fields. The findings and recommendations will contribute to future research and have the potential to be applied in appropriate graphic design disciplines, with implications for both academia and industry. Through creativity, accessibility, and user engagement, the finding will seek to foster a new approach toward more engaging and user-centric experiences in the new dimensions of visual communication.

Keywords: *NFC Technology, Graphic Design, Educational context, Trends*

INTRODUCTION

Malaysians spend 4 hours and 49 minutes a day looking at their phones (Howarth, 2023). With a user base

of over 33 million, Malaysians are among the most tech-savvy people in the world (Howe, 2023). In Digital Malaysia 2023, Datareporter.com said that between 2022 and 2023, the number of active mobile connections among Malaysians went up by 2.9% (1.2 million) and reached an impressive 44.05 million, which is 129.1% of the country's total population of 34.13 million in January 2023 (Meltwater, 2023). The rising popularity of mobile commerce, wearables, and smartphones has contributed to the widespread utilisation of over 2 billion Near Field Communication-enabled devices worldwide (NFC Forum, 2023). This scenario indicates that people simply tap their smartphones to find information and shop. Since NFC-capable smartphones are popular, it will benefit brands and retailers to actively engage consumers.

Information technology is seeing rapid growth, emphasising the mobile sector, which is expanding rapidly and being implemented across numerous new areas. Between 2018 and 2020, new NFC activations experienced a substantial 71% increase, and NFC interactions increased by 63% over the same period. The growth trend continues, with a projected 1.6 billion NFC-enabled devices anticipated to enter the market by 2024. Looking beyond NFC, the numbers become even more impressive when considering the Internet of Things (IoT). By the year 2030, it is projected that approximately 500 billion IoT-enabled devices will be in use worldwide. As the demand for contactless technology rises, NFC is predicted to find widespread adoption beyond just payments, especially within the IoT landscape (Aanerud, 2022).

In education, NFC-Powered Graphic Design incorporates Near Field Communication (NFC) technology into visual communication strategies to enhance the educational experience. Graphic design in this context uses visual attributes such as images, graphics, videos, and interactive displays to convey information and engage the audience. In graphic design, print material is an essential component that has been used for centuries and continues to play a significant role. Despite the declining popularity of printing technology, its contribution remains relevant. The previous COVID-19 pandemic has encouraged significant shifts in the graphic design landscape, promoting greater emphasis on interactivity. Businesses and manufacturers now emphasise user engagement as a critical component of their marketing strategies, aiming to elevate the overall user experience. Mobile tagging is a potential solution to this challenge by fulfilling technological requirements and serving as a marketing tool that connects both the phygital (physical and digital) worlds (Infineon, 2023) through a single tap.

NFC is a wireless communication technology that facilitates data transfer between devices over short distances, eliminating the requirement for an Internet connection. NFC tags can assist consumers in obtaining additional information about a brand's products, both before and after making a purchase. By utilising their NFC-enabled smartphones to scan the NFC tag, consumers can retrieve a wealth of information about the brand, its products, their origins, and any existing product discounts, among other relevant details. In today's rapidly changing retail market, brands and retailers must find new and innovative ways to engage with customers. Conventional methods may need to be revised due to market changes (Bick, et al., 2022; Reinartz et al., 2019).

Visual communication involves conveying ideas, data, and information through signs, typography, drawing, graphic design, illustration, environmental design, advertising, animation, and electronic resources (Ji & Lin, 2022; Yu et al., 2022). Consumers require more than just images to convey and convince them. Improving smartphone technology research and development will allow creative players to offer better user experiences. However, technology integration in graphic design still needs to be explored in existing literature. Most current research has primarily centred on implementing NFC-enabled packaging in industries, showcasing its emergence as a cutting-edge trend in intelligent packaging driving active brand engagement. NFC can generate interactive user experiences—for example, the embedded NFC tag in printed materials such as posters, flyers, or brochures. When a user's NFC-enabled

smartphone or device comes into proximity to the tag, it triggers an action or response. These could be opening a website, displaying additional content, launching an app, or initiating a transaction, among other possibilities. Additionally, NFC technology can be incorporated into digital signage and interactive displays (Khalil et al., 2023). Users can interact with the displays by tapping their NFC-enabled devices, allowing for a more personalised and engaging experience. NFC can also be utilised in retail environments to enable contactless payments, access to product information, or participation in loyalty programs, all contributing to a seamless and interactive visual communication experience. NFC tags have many uses in educational settings, such as enabling interactive learning experiences, managing library resources, monitoring attendance, setting up digital centres, creating assistive tools for students with visual impairments, and providing additional information (Coskun et al., 2015). Utilising NFC technology's advantages enables instructors to create creative, practical solutions that meet their students' specific requirements and preferences (Coskun et al., 2013). Considering the significance of preparing students for the challenges of the Fourth Industrial Revolution (IR4.0) and facilitating new learning experiences using technology, an effort to explore the potential of NFC-embedded visual communication disciplines is needed. By identifying potential benefits, challenges, and applications within educational settings, the study seeks to enhance the learning experience.

There is a limited usage of NFC integration in educational settings (Tarang, 2017), particularly in the fields of graphic design and visual communication. Due to the cost and lack of knowledge regarding the incorporation of technology, many small businesses refrain from adopting NFC technology, and the educational sector, especially in graphic design and visual communication settings, remains passive. These limitations in NFC technology adoption may involve difficulties in seamlessly incorporating NFC technology into project designs, limited access to NFC-enabled devices for testing and implementation, and a lack of comprehensive resources and guidance (Gegeckienė et al., 2022) on effectively utilising NFC in student projects. The main issues discussed include low familiarity, technology adaptation, and sustainability. Therefore, the primary objective is to explore how to empower students to harness the full potential of this significant technology in creating interactive and innovative graphic design and visual communication projects.

As a result, there is a significant gap in our understanding of how NFC can be optimally employed in educational settings and how it can be leveraged to improve learning experiences for project-based learning, focusing on its usability, attractiveness, and advantages (STMicroelectronics, 2021). This study will address this gap by investigating the integration of NFC technology within a graphic design educational setting, including the key features, functions, and benefits of NFC technology's potential. By bridging this gap, the study will provide valuable insights and encourage students' active participation, retention of knowledge, and enjoyment of the learning process, thereby improving educational outcomes.

LITERATURE REVIEW

NFC technology integration refers to incorporating Near-Field Communication (NFC) technology into various visual communication methods and platforms. It operates based on electromagnetic induction, like radio-frequency identification (RFID) technology. This technological process will bridge the gap between traditional media and mobile-centric lifestyles by utilising two dimensional barcodes scannable by a mobile phone's camera (Ebner & Maierhuber, 2013). It enables customers to access information through these tags, containing data displayed on their mobile devices. Typically encoded in a

two-dimensional barcode format, these tags are read by a smartphone's camera during the mobile tagging process. This approach has gained significant popularity in Asia, notably in Japan, where it was first introduced in 2003. Since then, mobile tagging has been extensively utilised in various aspects of mobile marketing. Its success can be attributed to its versatility, diverse applications, and the ability to provide swift, accurate, and user- oriented access to information.

Related NFC Studies

Several NFC service areas and applications are revealed through academic databases, technology news websites, and industry sources. These encompass areas such as Healthcare, Smart Environments, Data Exchange and Sharing, Mobile Payment, Ticketing and Loyalty, Entertainment, Social Networks, Educational Services, Location Workforce, Retail Management, and Tourism (Aydin & Ok, 2010; Coskun et al., 2013; Hamzah et al., 2019). A recent study offers insights into the utilisation of NFC in both Smart packaging and Active packaging, highlighting them as emerging trends within the packaging industry, mainly in the food industry (Đurđević et al., 2018; Madhusudan et al., 2018; Rydzkowski et al., 2022; Young et al., 2020b).

The utilisation of NFC (Near Field Communication) technology in educational settings, particularly in visual communication, is an area in need of extensive research and integration. While NFC technology has great potential for enhancing communication, engagement, and information access, its implementation in educational settings remains limited (Coskun et al., 2015). Prior research has suggested that banking and payment systems have been the most common sectors for using NFC technology (Hamzah et al., 2019). Supported by existing literature, it offers an understanding of the advantages, technical features, and customer engagement of the user experience and purchasing behaviours (Gegeckienė et al., 2022; Karpavi et al., 2023; Mooiman et al., 2023; Young et al., 2020b).

NFC Technology

"Near Field Communication" refers to wireless communication or ultra-short length range between two NFC-compliant devices with a 2 to 10 centimetres transmission range and a standard worldwide frequency of 13.56 MHz with power harvesting limited to 1W. It is based on radio frequency identification (RFID) technology. It enables compatible hardware to control and exchange data with unpowered and passive electronic identifiers using radio waves with data rates from 46 kbit/s up to 1.7Mbp/s. NFC chips come in three types: NFC readers, NFC tags, and NFC controller chips. NFC accomplishes this using electromagnetic induction and passive tags, eliminating the need for the device to contain its power source. The connection between the emitter or reader/writer and the tag or card establishes the primary method of NFC communication. The emitter and tag antennas are connected via an electromagnetic field, and an alternating current travelling through the primary coil (Emitter) induces an electromagnetic field in the secondary coil (Tag). The controller chip, a customised CPU (Central Processing Unit), processes instructions from the application processor software to recognize NFC tags or read tag content.

It has small chips that can be put on labels or built into products. These tags store information that NFC-enabled devices can read. They make storing much information accessible, like contact information, web addresses, and even small data sets. The NFC protocol has two ways of communicating with each

other: active mode (NFC reader chip) and passive mode (NFC Tag) (STMicroelectronics, 2023). Both devices make their own RF fields to send data in active communication mode. In passive communication, only the initiator makes the RF field. The target device utilises the energy already made (Mooiman et al., 2023). The foundation of NFC is the 'Tap' experience, and the primary characteristics include Small Data Payload, Power Sensing, Remarkably Fast Startup, and Short Connection. The NFC Forum has defined five NFC tag sizes and shapes to facilitate various implementations. Ranges and reading areas are affected by several factors, including antenna position, antenna size, antenna quality, the impact of nearby components, and power level (NFC Forum, 2023). The antenna may be located at the device's top, middle, or bottom, but most NFC antennas on new smartphones are at the top.

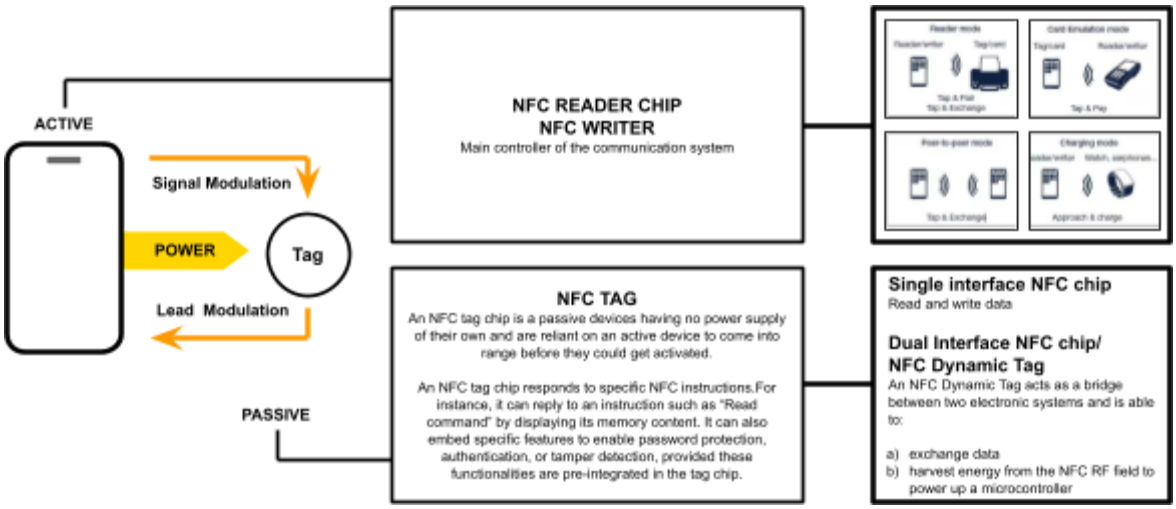

Figure 1. NFC system and operating modes
(Source: NFC Forum, 2016)

NFC communication uses three types of NFC devices: smartphones, NFC tags, and NFC readers. Most Android and iOS devices are equipped with NFC. Industry white papers say that NFC can be divided into six different modes. These are Reader mode, Peer-to-Peer mode, and Card Emulation mode. In reader mode, a device with NFC can read information from an NFC tag or card. Peer-to-peer mode allows two NFC-enabled devices to send data to each other, and card emulation mode lets an NFC-enabled device operate like a credit card or access card (Coskun et al., 2015; NFC Forum, n.d.; STMicroelectronics, 2022). Other modes mentioned by the NFC Forum include wireless Charging mode, Host Card Emulation (HCE), and Secure Element- Based Card Emulation. Wireless Charging sends up to 1W of power over NFC in a dedicated way. Communication ensures power transfers. This mode charges low-power devices like styluses, headsets, fitness trackers, and smartwatches. The Device Host's HCE application simulates contactless cards. The Device Host receives all contactless commands from the NFC Controller. The HCE application can then communicate with the contactless reader via the NFC Application Programming Interface (API), and Secure Element-Based Card Emulation replicates the contactless card for added security, ensuring the transaction is as secure as a contactless smart card (Forum, 2023).

Previously, the NFC chips were mistaken for an expensive component, yet they can now be purchased reasonably (Lackner, 2019; Mooiman et al., 2023). When tags are purchased in significant quantities, they become more cost-effective, creating more opportunities for inexpensive products to

implement the technology. Obtaining product information, receiving in-store discounts, gaining access to links on the brand's social media profiles, receiving how-to instructions, and verifying the product's authenticity were just a few of the numerous applications for NFC-enabled products. For instance, businesses utilised NFC technology in product packaging to add augmented reality (AR) and gamify the experience.

Additionally, the NFC is practical due to the element of product traceability, followed by consumer engagement, which results in the management of items to be trackable (STMicroelectronics, 2022). Products can be geographically located everywhere and along the whole supply chain using a smartphone, from manufacture to shop. As a marketing tool, the applications for NFC labels are practically limitless. Today's technology connects individuals and will offer countless opportunities to make our daily lives easier (Young et al., 2020a). NFC can be implemented differently on mobile devices, which can directly impact how users interact with them (STMicroelectronics, 2021).

Integrating NFC tags into high-end products offers a potential solution to the issue of counterfeiting while simultaneously enhancing the overall user experience (Infineon, 2023). Luxury brands incorporate NFC technology to combat counterfeit items. NFC chips increase brand loyalty and trust by enabling people to tap, link, engage, and create unique relationships with a company's brand before and after purchasing. Businesses that enhance their physical products with an engaging digital customer experience have a greater chance of succeeding in a highly competitive market. It means buyers can use digital technology to verify product authenticity. In accordance with their recommendations, the NFC Forum established an internationally recognized symbol known as the NFC logo or 'N' mark. This symbol serves the purpose of assisting consumers in identifying the precise location of an NFC tag. The logo is provided at no cost, but using it requires the company's acceptance of the N- Mark Trademark License Agreement. Furthermore, the NFC Forum has created and endorsed the "wayfinding mark system" to ensure a consistent user experience. Once again, it is necessary for those using the trademark to agree to the terms and conditions outlined in the Wayfinding Trademark License Agreement.

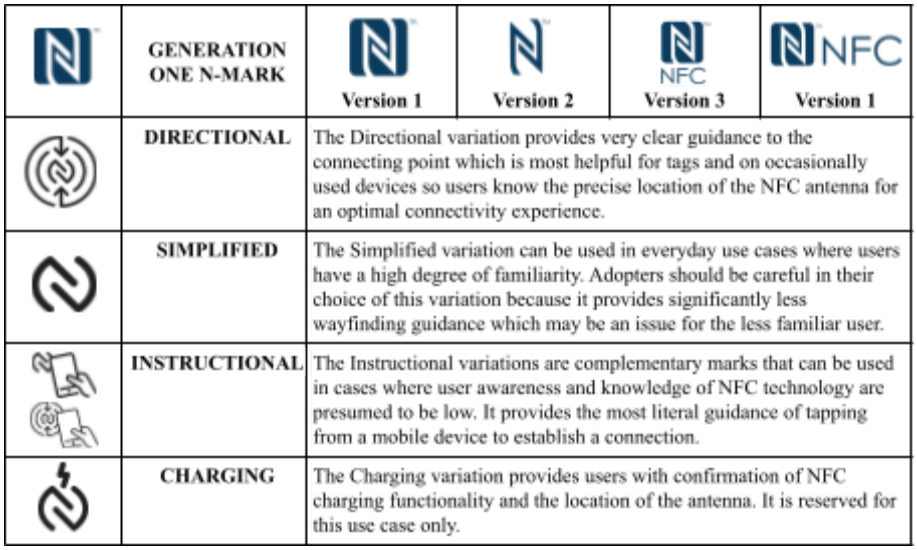

Figure 2. N-Mark and Wayfinding mark logo
(Source: NFC Forum, 2016)

NFC Technology in Graphic Design Educational Setting

In graphic design education, a pedagogical approach called project-based learning (PBL) provides students with hands-on and actual experience. PBL enables students to actively interact with the material and use what they have learned to complete their project. This teaching method encourages the growth of critical decision-making and problem-solving skills. Designing creative teaching methods and incorporating technology into the curriculum is crucial to holistically growing students' talents (Hajj & Harb, 2023). The exploration of NFC technology within the context of graphic design in this study will provide a better understanding for lecturers and students. To delve deeper, a case study involving actual companies encourages students to be more self-directed in their learning, take responsibility for their work, and make decisions by facing real problems.

Touchless technologies, including IoT sensors, gestures, real-time hand interaction, and NFC (Ebner & Maierhuber, 2013; Iqbal & Campbell, 2021) has become an emerging trend in education to develop intelligent academic systems. The potential of NFC and their implementation in the educational context includes distributing lesson materials, adding information to materials, sharing materials, releasing lesson results, integrating social networks, controlling access to materials, and controlling access to permitted media to be used during exams (Ebner & Maierhuber, 2013; Patil, 2023). Furthermore, NFC technology can improve the learning experience, facilitate administrative duties, and increase overall productivity. These include student identification and access control, library management, mobile payments and campus services, interactive learning, campus events and access, campus navigation, and campus security. NFC solutions can help to speed up administrative tasks and enhance the learning experience while contributing to a more connected and accessible campus environment (Dai et al., 2023).

RESEARCH METHODOLOGY

The qualitative approach will provide an introductory overview of the integration of NFC technology, specifically in the context of graphic design education. By analysing current literature, this study seeks to understand NFC research as a social science field to offer insights to NFC practitioners, researchers, and students. Representative of the most recent NFC literature, the survey's time frame was limited to 2020–2023, using the search descriptors NFC In Design, NFC In Creative Design, NFC Technology Graphic Design, and NFC Technology in An Educational Setting. This study investigates the potential uses of Near Field Communication (NFC) technology in graphic design and explores the potential learning outcomes derived from its usage.

Due to insufficient research in the field, this study seeks to provide an introductory overview of NFC technology and its underlying technology that will benefit the field. The capabilities, potential benefits, and applicability will be determined. A pre-study questionnaire was conducted to gain familiarity with NFC technology among the participants. They are seventeen final-year undergraduate graphic design students who major in illustration and packaging design disciplines. They employed a local SME company as their selected case study, with a duration of two semesters (8 months) following the academic calendar. The findings of this study will be applied in their final project development, with implications for both academia and industry. Through creativity, accessibility, and user engagement, the findings of this study seek to foster a new approach towards more engaging and user-centric experiences in the new dimensions of visual communication.

FINDINGS

Pre-Study Questionnaire

Seventeen (N =17) undergraduate students were involved in this study. The purpose is to seek familiarisation with NFC among these students. A pre-study questionnaire was distributed, and they were asked about their details and what type of smartphone they were using. It also inquired about the basics of NFC, whether they were familiar with the terms, the differences among NFC, Bluetooth, and QR codes, whether their smartphone was equipped with NFC, and whether they could explain how NFC is used in everyday life. In the second section, we inquire about the basics of NFC technology. Compatibility, tap experience, knowledge of NFC in graphic design, tools or apps can be used to prepare files for NFC material production. Finally, do they agree whether this technology will enhance or reduce the value of their final project?

The pre-study data shows that 11 use the Android platform, and only nine are familiar with NFC. 10 smartphones were NFC-enabled with iOS and Android operating systems. They are familiar (N = 11) with NFC, but half need help understanding the differences between NFC, Bluetooth, and QR codes. The description of how NFC technology is used in everyday life is presented in Table 1.

Table 1. Descriptions on how NFC is used in everyday lives.

Participants	Descriptions
P1	*"For cashless payment (using card bank)"*
P2	*"Smart packaging and save data"*
P3	*"None"*
P4	*"Music can be scanned using NFC"*
P5	*"To do online transactions"*
P6	*"Virtual reality"*
P7	*"Can be use in smart tag"*
P8	*"Touch & go"*
P9	*"Not care"*
P10	*"Card payments"*
P11	*"No idea"*
P12	*"Can pair with another device"*
P13	*"NFC touch and go that can easily reload our balance directly scan in mobile phone"*
P14	*"I don't know"*
P15	*"NFC allows me to do any contactless payment to others.As (For) example when I want to pay my phone bills."*
P16	*"Cashless payment using (a) card in (the) market or other."*
P17	*"No idea"*

Understanding the compatibility between NFC devices (as shown in Table 3) is crucial for ensuring the adoption of NFC technology in a reliable, secure, and extensive manner. The knowledge will assist students in understanding the different NFC modes. Even though they are familiar with NFC, they must realise that 'Tap & Connect' is one of the NFC connection strategies (N=9).

Table 2. Knowledge of NFC device compatibilities

Numbers of responses	Percentage	Description
2	11.76%	*"Don't know"*
1	5.8%	*"I think so"*
3	17.65%	*"I'm not sure"*
8	47.06%	*"Yes"*
17	100%	

As mentioned, there is still limited usage of NFC in a graphic design context. However, due to collaborative discussion and brainstorming activities, the participants may read and find related information about the common usage of NFC in graphic design. As a result, we identified potential ideas to be developed for their project study (refer to Table 3).

Table 3. The descriptions whether participants have any common use of NFC in graphic design

Participants	Descriptions
P1	*"No"*
P2	*"Smart packaging and save data"*
P3	*"No"*
P4	*"Like a fingerprint, it consists of a circle of round shapes"*
P5	*"Make the artwork unique"*
P6	*"User interaction?"*
P7	*"I'm not sure"*
P8	*"No"*
P9	*"Not care"*
P10	*"Scanning for information in Packaging Design"*
P11	*"Don't know"*
P12	*"Yes, because people can get new information easily"*
P13	*"Not really sure"*
P14	*"No"*
P15	*"Use NFC in packaging design (is) interesting. This can make consumers gain more information about the products."*
P16	*"Yes to make t easier for users to access to other websites for example product websites"*
P17	*"No"*

Despite their need for more understanding and information regarding the various applications of NFC technology, they agreed that it would help and add value to their project (N = 17). Since the previous artwork and thoughts were practically presented in a standard graphic design manner, incorporating this technology may give them a new viewpoint on their learning capacities and a better learning experience. Since only 11.8% (N = 2) of total participants knew the tools or software for preparing files for NFC production, more effort and reference needed to be put into finding appropriate and accessible NFC tools for them to use.

The Applicability of NFC

NFC essentially applies the tap or near-touch sensation. The user's smartphone is brought closer to the touchpoint with the tag to initiate the action. When the NFC tag is scanned, the program will instantly launch and connect to the internet for information via either a mobile network or Wi-Fi. The connection range of built-in NFC in smartphones is commonly mid-range applied to Android and iOS platforms. The chips differ based on the type of tags and for a specific use. The Ultralight, Ultralight C, Standard (Classic) 1K, Desfire 4k, and the brand-new NTAG203 are a variety of NFC device chips. It can have different amounts of memory, writing, and reading speed, protecting against collisions when two sources transmit data simultaneously to meet different requirements (Serialio, 2021).

The consideration of temperature-resistant, interference-resistant, or water/chemical-resistant is needed before selecting any NFC tag type to suit a specific working environment. Hence, the tags come with different casing and materials to fulfil the indoor setting, outdoor, and high-interference environments. Additionally, the tags can be found in various forms, sizes, and thicknesses (as shown in Table 4).

Table 4.Various types of tags

Types of NFC TAG	Specifications
Sticker Tags	Radio Frequency Identification (RFID) tags equipped with a self adhesive backing, Tags are available in manat forms and sizes and can be obtained in the forms of rolls or strips. Frequently employed for the purpose of inventory management.
Badges & ID Cards	Ab UD badge ir card that contains an (RFID) device. Possibly empty or customizable with logo and/ or image. Commonly used for employee access control credentials at work, school, and membership organisations.
Anti metal Tags	Specifically designed for metal and metallic surfaces These are typically employed for industrial and business applications.
PROX Tag	A ‘contactless’ smart card or key fob that is scanned by an RFID reader. Utilized frequently for security and access control
Livestock Pet Tags	Typically, an RFID wand or RFID antenna is used to scab these tags. Usually used to identify track and keep an eye on livestock and is frequently connected to the animal’s ear and as a pet identification.
Jewellery Tags	Jewellery tags range from paper-like stickers to plastic tags with holes punched in them and more. They are great for keeping track of small things and keeping an inventory.
Wristband Tag	Come in a wide range of materials, styles, colours, and sizes. One-time use and reusable are two of the most popular types. The most common materials are paper, soft PVC, and rubber.
Laundry fabric Tags	Fabric tags are sewn into clothes, sheets and other fabrics that are made to last through many washings. Most are made of silicon or PPS that is covered with epoxy.
Carrier Tracking Tags	Typically they are clip-on clamp, zip tie, hanging tag or lanyard based for temporary or permanent attachment to carriers in manufacturing procedures.

Throughout the study, NFC (Near Field Communication) technology offers various applications in graphic design and creative fields. The appropriate capability for using NFC technology in graphic design is developing NFC- embedded material and NFC-embedded project artworks. Significant research from various graphic design areas, such as publishing, advertising, packaging, visual merchandising, and portfolios, including virtual reality and game-based learning, can collect a few forms of graphic design materials.

NFC-enabled posters, brochures, business cards, and packaging can be designed to initiate a specific action when contacted by an NFC-enabled device. A website or promotional details could be accessed via a link by touching the tag, creating an interactive experience for potential customers. In addition, conventional books, magazines, and standard e-books can be transformed into interactive storytelling. To enhance the reading experience, this can be accomplished by adding multimedia elements such as videos and animation. Additionally, scholars mentioned that intelligent and active packaging has become an emerging trend, especially in the food industry. This factor will lead the study since it proved that the NFC-enabled packaging managed to engage consumers uniquely and provide more than what they read on the label.

Regarding brand engagement and loyalty, counterfeiting can result in significant losses, a decline in customer trust, and a negative impact on a company's reputation and brand engagement. NFC technology assists in protecting the brand's reputation by detecting the product's authenticity and origin. They are typically used for luxury brands, pharmaceutical products, recreational goods, and health and wellness products. Other than that, the easy accessibility of product information can be utilised to customise promotions and discounts. It will provide exclusive offers for members or recommendations according to their preferences.

The potential of NFC technology could be further extended to support the preservation and promotion of art and heritage. Consumers may get the information, artist statement, and artwork value with a single tap. The museum and gallery may use NFC technology to provide information about the artefacts and the historical context. In fact, due to cost and sustainability concerns, some exhibitors and event organisers have recently adopted NFC technology to facilitate the users. Event materials, including admission tickets, the event schedule, speaker or artist biographies, directions, directories, and even special needs information, were instantly accessible. Creating an outstanding design portfolio is **e**ssential for artists and graphic designers. It symbolises both designers and the value of ideas. The artwork will be presented digitally through the NFC-embedded portfolio, offering a unique experience to clients or employers. Augmented reality and gamification are other potential results of using NFC technology (Choi, 2022).

The Benefits of NFC

Previous studies discussed that implementing NFC in education is significant in developing an intelligent academic system (Iqbal & Campbell, 2021). Advanced technology serves an essential role in education. Adaptation is crucial due to the development of digital devices with advanced features. The underlying values of NFC rely on its operating mode. It facilitates integration and makes human interaction simpler. In the graphic design context, it provides interactivity, which captivates the user's attention and provides a memorable experience. The technology will increase user interaction and make Consumer Packaged Goods (CPG) smarter. Using NFC in graphic design can get people more interested in a brand, product, or message. It allows designers to connect the gap between physical and digital media, enabling consumers to access more information, multimedia content, offers quickly and calls to action. Consequently, it will enhance branding and provide a unique perspective. On the other hand, the NFC-enabled materials will provide real-time updates, and clients will simultaneously be informed with dynamic information.

Another advantage of employing NFC technology is the capacity to track, analyse, trace products, and manage stocks, especially in substantial supply chains. The good is managed to be geolocated from

anywhere along the supply chain (STMicroelectronics, 2018). It was suggested that the label must be marked for easy identification and access throughout the supply change. Tech- savvy consumers are always looking for unique and interactive experiences. NFC technology will assist designers in remaining relevant and providing clients with personalization. Using these methods, the designer will create the material following each person's demands and preferences. This strategy helps promote sustainability and reduce the cost of printing materials. The mistakes or updates could be amended and restored remotely. The modifications to the information will continue to be relevant by linking to the digital content. Furthermore, people who were good with technology usually had more than one device. Different supported NFC devices allow cross-platform compatibility. Interacting, communicating, and getting engaged are all much easier and quicker. So, the interaction gives essential marketing information. The marketers find out about the most famous activities and locations, which will help them improve their marketing strategy.

The Capability of NFC

Most studies show that NFC technology is widely used in the contactless payment ecosystem. Secure payment can be made using a smartphone on NFC-enabled terminals (Fauzan et al., 2022). It revealed that NFC technology is also widely used in secure access control systems. NFC-enabled access cards and ignition keys are typically used to grant access to facilities. This access control was also implemented in public transportation systems and smart home devices. NFC enormously contributes to the medical and healthcare area (Hamzah et al., 2019). NFC facilitates medical records, devices, systems, staff carrying activities, healthcare data, clinical data, and patient identifications. NFC technology develops business and expands networking. The exchange of business information is more manageable and convenient for professionals to stay connected. It also supports sustainability efforts by reducing unwanted waste from various printed materials. At the same time, it is very convenient for gamification. The strategy of the gamifications, AR integration, and 360º video could be accessed and provide different and interactive experiences.

NFC integration graphic design educational settings are not restricted to learning outcome items. NFC tags will assist in the effort to create an intelligent academic system by being incorporated into educational materials like textbooks, tutorial videos, notes, and formative assessment instruments. At a physical store's point-of-sale (POP), NFC may be utilised to gain customers' interest. Wayfinding, information kiosks, and digital signage are examples of potential materials designers may create to assist customers in finding their desired store, particularly in large shopping malls. In addition, the NFC tags can collect feedback or conduct surveys regarding visual content and provide data for content creators. The integration of physical and digital content, enabled by this technology, has proven to be a valuable resource for professionals across various areas, such as marketing, art, education, and visual communication within the business sector.

Challenges Using NFC Technology

Implementing NFC technology in graphic design comes with challenges and requires full consideration of various factors despite its numerous benefits and applicability. Cost is one of the most important factors influencing the application of NFC in graphic design. Adding NFC technology to print materials, packaging, and promotional goods may increase production costs. The price tag reflects the investment in developing and testing NFC tags, hardware, and software capabilities. Compatibility varies

by device. Not all smartphones and devices support NFC. Access is limited because users require appropriate devices to use NFC IDs. This study also highlights NFC communication range limitations that require proximity. A short distance range (2 to 10 cm) is required for NFC communication, which may not be feasible for larger or distant objects. The other challenge of using NFC is limited storage capacity. The limitation requires designers to optimise and use the available space to store relevant and appropriate data precisely. These require proper content management and planning.

Due to the limited review of NFC in graphic design education and its relatively recent, it requires suitable assistance, education, and awareness. Instructions on using technology and getting familiar with it should be properly initiated. An effort must be made to publicise the technology and its benefits, particularly in education. These will result in a greater understanding and adaptation of technology. The challenge of privacy concerns and security perceptions is another obstacle to the adoption of NFC technology. The main issues restricting NFC adoption in specific applications include data breaches of sensitive information and unauthorised financial transactions. This matter should be seriously considered, particularly concerning security measures like encryption, which are crucial for safeguarding sensitive information. Finally, there is the technical challenge and expertise. A successful integration of NFC requires experienced and expert advice. The devices differ in functionality, so other nearby electronic materials or devices that interfere with communications may affect the technology. When implementing NFC applications, it is crucial to consider the physical environment and surrounding factors.

CONCLUSION

This study will assist in a better understanding of the practicality of NFC- enabled graphic materials. It enables businesses to dynamically enhance their products and services to adapt to customer needs. Industry white papers and non-profit industry organisations, such as the NFC Forum, have raised awareness and aggressively promoted the use of NFC technology. The details, specifications, and benefits were extensively shared, tested, and endorsed to educate the market. Even though the application appears to be limited to graphic design, the experiment and exploration of this study should be carried out. The practice may differ even in today's academic papers, which are primarily published in conferences and journals.

In summary, exploring the application of NFC (Near Field Communication) technology in graphic design within an educational setting exposes fascinating possibilities. By employing NFC technology in this context, conventional educational materials can be transformed into dynamic and engaging learning tools that enhance the educational experience for both students and instructors. Technology must be adapted to meet industry needs. Providing an overview of NFC applications and services in a graphic design educational context will lead to the actual implementation or development of the prototype. Reviews and preliminary research indicate that novice designers would greatly benefit from acquiring Near Field Communication (NFC) technology knowledge and skills. Observation and evaluation, such as experimental, testing, or field study, are needed for further research. The survey study has provided a better understanding of the NFC technology and the current NFC ecosystem. Due to its popularity and implementation in more extensive sectors, Intelligent Packaging, Smart Packaging, and Human Interaction have recently been among attractive research areas for many researchers. However, further research may also be valuable, specifically on other graphic design and visual communication areas within the education context.

The area of research could be extended to gain a deeper understanding of the application using systematic guidelines and proper tools. Actual material or prototypes could be developed using field study, exploration, and testing to understand the NFC ecosystem further. The insights from this research could assist education members, especially in graphic design, developing effective project materials, and supporting intelligent academic systems. At the same time, it will enable students to employ the maximum potential of this significant technology to create interactive and original graphic design and visual communication projects.

ACKNOWLEDGMENT

We are deeply grateful to all the educational institutions and experts who have graciously contributed their valuable thoughts, experiences, and resources to enrich the content and outcome of our study. Their essential contribution has significantly improved the quality of our paper, and we could not have achieved such remarkable results without their support. Finally, we thank all the companies, students, and educators who gave us helpful feedback, making this study a genuine group effort.

REFERENCES

Aanerud, E. (2022). *AM Integrating NFC Technology in Performing Arts Organizations*. https://courses.ideate.cmu.edu/62-830/s2022/?p=490

Aydin, M. N., & Ok, K. (2010). *NFC Research Framework: A Literature Review And Future Research Directions Increasing Cumulative Connected Coverage in Wireless Sensor Networks by Relocating Sensor Nodes View project Insurance fraud View project*. https://www.researchgate.net/publication/228853536

Bick, R., Bout, S., Frick, Fabian, K.M., & Skinner, V. (2022). *The tech transformation imperative in retail* (Issue May). https://www.mckinsey.com/industries/retail/our-insights/the-tech-transformation-imperative-in retail#/

Choi, K. S. (2022). The Use of Augmented Reality Technology in Mobile Advertising. *The Treatise on The Plastic Media*, *25*(3), 200–206. https://doi.org/10.35280/KOTPM.2022.25.3.22

Coskun, V., Ozdenizci, B., & Ok, K. (2013). *A Survey on Near Field Communication (NFC) Technology. Wireless personal communications* (Vol. 71, Issue 3). http://link.springer.com/article/10.

Coskun, V., Ozdenizci, B., & Ok, K. (2015). The survey on near field communication. *Sensors (Switzerland)*, *15*(6), 13348–13405. https://doi.org/10.3390/s150613348

Dai, Z., Xiong, J., Zhao, L., & Zhu, X. (2023). Smart classroom learning environment preferences of higher education teachers and students in China: An ecological perspective. *Heliyon*, *9*(6). https://doi.org/10.1016/j.heliyon.2023.e16769

Đurđević, S., Novaković, D., Kašiković, N., Zeljković, Ž., Milić, N., & Vasić, J. (2018). Nfc Technology And Augmented Reality In Smart Packaging. *International Circular of Graphic Education and Research*, *11*. https://www.internationalcircle.net/international_circle/circular/issues/18_02/ICJ_11_2018_06

Ebner, M., & Maierhuber, M. (2013). Near Field Communication - Which Potentials Does NFC Bring for Teaching and Learning Materials? *International Journal of Interactive Mobile Technologies (IJIM)*, *7*(4), 9. https://doi.org/10.3991/ijim.v7i4.3019

Fauzan Aris, Kamisah Ismail & Suhana Mohezar.(2022). Fostering Mobile Payment Adoption: A Case Of Near Field Communication (NFC). *International Journal of Business and Society*, *23*(3), 1535–1553. https://doi.org/10.33736/ijbs.5180.2022

Gegeckienė, L., Venytė, I., Karpavičė, J., Tambo, T., Vaitasius, K., & Pauliukaitis, D. (2022). Near Field Communication (Nfc) Technology In The Packaging Industry. In *International Symposium on Graphic Engineering and Design*. https://doi.org/10.24867/GRID 2022-p54

Hajj, M. El, & Harb, H. (2023). Rethinking Education: An In-Depth Examination of Modern Technologies and Pedagogic Recommendations. In *IAFOR Journal of Education: Technology in Education* (Vol. 11).

Hamzah, M. L., Purwati, A. A., Desnelita, Y., Rusilawati, E., Kasman, R., & Rizal, F. (2019). A review of Near Field Communication technology in several areas. *Revista Espacios*, *40*(32). https://doi.org/https://www.researchgate.net/publication/336774868_A_review_of_Near_Field_Communication_technology_in_several_areas

Howarth, J. (2023). *Alarming Average Screen Time Statistics (2023) Average Screen Time Stats 2023*. https://explodingtopics.com/blog/screen-time-stats

Howe, S. (2023). *Sue Howe*. 1–29. https://www.meltwater.com/en/blog/social-media-statistics- malaysia

Infineon. (2023). *Experience the future of luxury with NFC*. https://www.infineon.com/cms/en/product/security-smart-card-solutions/optiga-embedded security-solutions/optiga-authenticate-nfc-solutions/?redirId=177455

Iqbal, M. Z., & Campbell, A. G. (2021). From luxury to necessity: Progress of touchless interaction technology. *Technology in Society*, *67*. https://doi.org/10.1016/j.techsoc.2021.101796

Ji, S., & Lin, P. S. (2022). Aesthetics of Sustainability: Research on the Design Strategies for Emotionally Durable Visual Communication Design. *Sustainability (Switzerland)*, *14*(8). https://doi.org/10.3390/su14084649

Karpavi, J., Abdel, I., Tambo, T., Chinello, F., Karpavi, J., Abdel, I., Chinello, F., & Centerpark, B. (2023). Science Direct Experimental approaches to NFC-enabled packaging for UX / CX Experimental approaches to NFC-enabled packaging for UX / CX of physical artefacts : A technology maturity study of physical artefacts : A. *Procedia Computer Science*, *219*(2022), 577–585. https://doi.org/10.1016/j.procs.2023.01.326

Khalil, G. A., Qutp, M. M., & Nada, M. A. (2023). Intelligent Billboards Targeted Advertising Systems. *Journal of Art, Design and Music*, *2*(2). https://doi.org/10.55554/2785-9649.1020

Lackner, C. (2019, May 6). *NFC Tags to Break 10 Billion Barrier by 2023 according to ABI Research*. Retrieved from https://www.linkedin.com/pulse/nfc-tags-break-10-billion-barrier-2023-according-abi-research: https://www.linkedin.com/pulse/nfc-tags-break-10-billion-barrier-2023-according-abi-research

Madhusudan, P., Chellukuri, N., & Shivakumar, N. (2018). Smart packaging of food for the 21st century – A review with futuristic trends, their feasibility and economics. *Materials Today: Proceedings*, *5*(10), 21018–21022. https://doi.org/10.1016/J.MATPR.2018.06.494

Meltwater. (2023). *Digital 2023 : Global Overview Report*. https://datareportal.com/reports/digital-2023-malaysia

Mooiman, N. & A. S., Lindh, M., Karpavi, J., Abdel, I., Tambo, T., Chinello, F., Karpavi, J., Abdel, I., Chinello, F., Centerpark, B., Kapse, S., Kedia, P., Kumar, A., Kausley, S., Pal, P., Rai, B., Gegeckienė, L., Venytė, I., & Karpavičė, J. (2023). Integrated NFC in product packaging. *Journal of Food Engineering*, *346*(May), 111424. https://doi.org/10.1016/j.jfoodeng.2023.111424

NFC Forum. (2023, August 06). *Technical Overview*. Retrieved from https://nfc-forum.org: https://nfc-forum.org/learn/nfc-technology/

Patil, J. (2023). SMART VISION OF IOT TECHNOLOGY AND DIGITIZATION IN VARIOUS AREAS OF ACADEMICS IN CURRENT ERA. *The Online Journal of Distance Education and E-Learning*, *11*(1), 851–859. www.tojdel.net

Reinartz, W., Wiegand, N., & Imschloss, M. (2019). The impact of digital transformation on the retailing value chain ☆. *International Journal of Research in Marketing*, *36*(3), 350–366. https://doi.org/10.1016/j.ijresmar.2018.12.002

Rydzkowski, T., Wróblewska-Krepsztul, J., Thakur, V. K., & Królikowski, T. (2022). Current trends of intelligent, smart packagings in new medical applications. *Procedia Computer Science*, *207*, 1271–1282. https://doi.org/10.1016/j.procs.2022.09.183

Serialio. (2021). *Common types of NFC tags*. Retrieved from https://serialio.com/: https://serialio.com/support/common-types-of-nfc-tags/

STMicroelectronics. (2018). *How NFC can help Consumer Packaged Goods companies grow their business*. https://www.st.com/content/st_com/en/search.html#q=how nfc can help consumer package-t=resources-page=1

STMicroelectronics. (2021). *How can NFC add value to your brand and enhance the user experience ?* https://www.st.com/content/st_com/en/search.html#q=NFC design considerations for an improved User Experience -t=resources-page=1

STMicroelectronics. (2022). *NFC a world of opportunities Contents*. https://www.st.com/en/nfc.html

STMicroelectronics. (2023). *What is an NFC Chip?* Retrieved from ST Life.Augmented: https://www.st.com/content/st_com/en/support/learning/essentials and-insights/connectivity/nfc/nfc-chips.html

Tarang. (2017). A Literature Survey on Near Field Communication (NFC). *American International Journal of Research in Science*, 17–215. http://www.iasir.net

Young, E., Mirosa, M., & Bremer, P. (2020a). A systematic review of consumer perceptions of smart packaging technologies for food. In *Frontiers in Sustainable Food Systems* (Vol. 4). Frontiers Media S.A. https://doi.org/10.3389/fsufs.2020.00063

Young, E., Mirosa, M., & Bremer, P. (2020b). *A Systematic Review of Consumer Perceptions of Smart Packaging Technologies for Food*. *4*(May), 1–20. https://doi.org/10.3389/fsufs.2020.00063

Yu, G., Akhter, S., Kumar, T., Ortiz, G. G. R., & Saddhono, K. (2022). Innovative application of new media in visual communication design and resistance to innovation. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.940899