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Visual-Related Factors in Mobile Iconic Communication

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UNIVERSITY OF NORTHERN COLORADO

Greeley, Colorado

The Graduate School

VISUAL-RELATED FACTORS IN MOBILE
ICONIC COMMUNICATION

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

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Department of Educational Technology

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This Dissertation by: Mohammed Alsuwailem

Entitled: *Visual-Related Factors in Mobile Iconic Communication*

has been approved as meeting the requirements for the Degree of Doctor of Philosophy in
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ABSTRACT

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The purpose of this exploratory, sequential, mixed methods design research was to explore current design trends and patterns in mobile application icons by analyzing existing icon elements and principles of design. The process of data collection and data analyses went through three main phases: (a) identify current characteristics and pattern design of existing icons, (b) compare mobile icons across selected application categories to underline how each category was different from the other regarding elements and principles of design used, and (c) explore users' perceptions about the elements and principles of design and account for how these elements and principles influenced the mobile application user's interaction. The results of the three phases concluded that in mobile iconic communication, the most impactful elements of design were color and graphics. It was also concluded that the icon's visual design had a significant impact on mobile usability, interaction, and communication whereby mobile developers were encouraged to design attractive, appealing and easy to recognize icons. The outcomes of this study emphasized the importance of graphic visual-design as a visual representative of the content and category of the application. Further studies are needed to explore the impact of other senses involved in mobile communication.

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CHAPTER I

INTRODUCTION

Background

Ubiquity of mobile technology is one of the 21st century's manifestations. Mobile technology has been widely used for different purposes. Recently, mobile devices have become a popular tool that supports learning, performing, and personal usages.

Designing for a mobile device has been and will continue to be immensely complex. For instance, the size of the screen and the evolution of touch-based screens are major themes characterizing mobile interface design. Therefore, to maximize the interaction between the mobile device and its user, it has been recommended that user icon-based recognitions be used as representations of mobile applications and features.

Huge numbers of mobile applications are published every day. In Google Play, for example, over 1,800,000 applications are available for download. Moreover, during the month of October 2015, 43,271 applications were published in Google Play alone. According to the International Telecommunications Union (ITU)/Information and Communication Technology (ICT) indicators database (2005), the number of personal computer users was two times larger than the number of mobile users. However, in 2015, the number of mobile users was two times larger than the number of PCs users, which confirms that mobile technology has taken the lead in terms of popularity.

Along with the growth of owning mobile technology, there is also growth in mobile application usage. The pervasive usage of mobile applications (mobile apps) has led mobile users to prefer mobile apps over mobile browsers when accessing a particular content. Statistical data presented by GO-Globe (Business 2 Community, 2014) showed several facts about how mobile apps have become very popular: (a) 89% of the time mobile users spent in mobile media was accessed by mobile apps; (b) every month, the average of downloaded applications is 26.92 apps per user; (c) adults spend over 30 hours every month using mobile apps whereas they spend less than four hours monthly using mobile web browsers, and (d) between the years of 2014 and 2015, the average time mobile users spent using mobile apps increased by 21%.

Problem of the Study

The rapid growth of mobile applications informed this research and prompted questions about the design of an application's icon for mobile devices. An icon is a "small image" that represents a single object or concept (Huang, Bias, & Schnyer, 2015, p. 702). In small-sized mobile technologies, it is common that mobile applications are displayed in the form of small-touch icons wherein the icons represent the concept of the application employed as the user interface (Im, Kim, & Jung, 2015). Yet, what are the patterns for designing a mobile application's icon, what are the visual-related factors entailed in the process of designing the icon, and what are the standards and the guidelines when designing a mobile application's icon? These questions need to be addressed and shared with application developers, instructional designers, and marketers.

Purpose of the Study

This research explored current design trends and patterns in mobile application icons by analyzing existing icon elements and principles of design. This visual exploration also highlighted visual design differences and similarities across different applications categories (news, sport, travel, social networking, education, and games). Additionally, mobile users' perceptions about mobile applications' icons were investigated to seek visual-related factors that affected users' interaction and communication with the application. Then users' perceptions and highlighted visual factors were discussed and evaluated regarding how they related to each other. The concept behind exploration is to understand in depth what visual factors affect mobile iconic communications.

A significant purpose of this study was a visual analysis to highlight characteristics and design patterns of mobile applications icons. The results of the study are expected to be beneficial for both mobile-applications developers as well as mobile users. It has been beneficial for application developers to follow current patterns when designing mobile icons. In other words, with no investigation of how existing mobile icons are visually designed, mobile developers follow their own personal or others' views in the designing process. Moreover, it is beneficial for mobile users to recognize the natural of the application by knowing its design patterns. Because designing mobile applications is available for everyone, i.e., Apple and Google Play offer online templates available for everyone to develop mobile applications, there is a need for research of current design patterns to provide some designing tips and roles that maximize users' interaction and communication during the process of icon design.

Research Questions

- Q1 (a) What visual elements are used in a mobile application's icon and (b) how do these elements vary across different application categories?
- Q2 (a) What design principles are used in a mobile application's icon, and (b) how do these principles vary across different application categories?
- Q3 What are mobile device users' perceptions about the visual design of mobile application icons?

Methodology

This goal of this study was to discover hidden visual factors in mobile application icon design. Similar studies have investigated icon recognition with regard to what elements and principles of design were used in designing the icon itself. Also, most of these studies used human "users" as primary data for the research. Yet, this study took a different direction in terms of its methodology by using a combination of data collection through human "users" and non-human "icons." Moreover, this study utilized a further step by comparing the outcomes of a visual analysis and users' perceptions.

The researcher used an exploratory, sequential, mixed methods design; qualitative visual-content analyses were followed by quantitative visual-content analyses. User interviews were conducted in the following phases.

1. Qualitative and quantitative comprehensive visual analyses of existing mobile icon elements and principles of design,
2. Mobile application users' perceptions toward mobile icon visual effects in user-experience and user-interaction.
3. Comparing the results of Phase 1's visual analyses to the results of Phase 2's the user interview.

The idea behind conducting a content-visual analysis was to seek meaningful outcomes of how the elements and principles of design were used in existing applications and how they were perceived by mobile application users.

Rationale/Significance of the Study

In general, the issue of designing interfaces has been well studied in different fields by different measurements and methodologies. However, according to current literature, there is a lack of studying the icon, which is one of the most important components of the interface utilizing visual analysis (Luo & Zhou, 2015). With the huge number of available applications, it was important to visually analyze current designing patterns of mobile applications' icons to seek factors involved in icon design. This would also maximize interaction and communication in different areas such as marketing, learning, playing, and so on.

Icon design plays an important role in touch-screened interface design. The new generation of mobile technology functions with touch-based screens that use icon recognition instead of text recognition since mobile users are more comfortable when using the touchscreen (Huang, 2012). In mobile interface design, there are challenges associated with a mobile interface. One of the most significant challenges in mobile interface design is the size of the screen (Gatsou, Politis, & Zevgolis, 2012; Huang, 2009). This challenge inspires mobile developers to innovate touch-based screens that operate with mostly image-based recognition, such as icons, instead of text-based. Different types of icons have been identified: logo-based, image-based, text-based, and symbol-based. These identified types of samples are used here as a variable of this research.

In terms of icon design, several attempts have been made to list standards and guidelines for designing an icon, e.g., GNOME (Benson, Elman, Nickell, & Reberson, 2004; Heim, 2007; Hooper & Berkman, 2011). These guidelines discuss different visual-related factors that affect user interaction. For example, GNOME's human interface guidelines (Benson et al., 2004) provides a section for icon design that shows how icons should appear as an important interface part, thus affecting user performance (Huang, 2012). Likewise, Heim (2007) stipulates the number of roles involved in icon design. Nevertheless, these attempts were not developed specifically for a mobile application.

However, these tips and guidelines were created for a computer-based icon design. It has been argued that the icons are different—whether they are being used by a personal computer (PC) or on a touch-screen device. In interface design, what is suitable for a PC screen might not work at all on a touch-screen device (Tidwell, 2011). It is not enough to reject guidelines that highlight the roles of icon design since the purpose of using the icon is the same for both PC and mobile devices--visual representation of a function or an application.

Definition of Terms

Elements and principles of design. The design elements are the visual components of every visual seen, e.g., dots, lines, shape, texture, color and pattern. Design principles are the embodiment of one or more design elements that creates a scene, e.g., contrast, balance, rhythm, proportion, and emphasis.

Human-computer interaction (HCI). A field that focuses on studies related to computer science, hardware, software engineering, etc. The HCI “seeks to understand

and support human beings interacting with and through technology” (Carroll, 1997, p. 62).

Iconic communication (IC). Use of images and symbols to convey information, ideas, or contents in a nonverbal manner (Lodding, 1983).

Interaction. A special kind of action that involves “two or more entities and a set of reciprocities that effect changes to each entity” (Marchionini, 2008, p. 170).

Interaction design. “Designing products to support the way people communicate and interact in their everyday and working lives” (Preece, Rogers, & Sharp, 2002, p. 8).

Mobile technology (MT). Any technology that has two important distinctions: portable (Zamfiroiu, 2013) and application-based.

Usability. “The capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of environmental scenarios” (Shackel, 2009, p. 340).

Visual communication. A base of communication that is non-verbal, which aims to understand, use, and communicate visually in an effective manner (Braden, 1996).

Summary

Owing to the size of the screen, it is common for mobile technologies or application-based technologies to use iconic communication as the primary interaction method between the user and the device. Yet, iconic communication, which is the use of small images or symbols to convey information in nonverbal manner (Lodding, 1983), requires further investigation in the matter of mobile technology. Based on the related

literature, there is lack of studying the icon, which is one of the most important components of the interface, utilizing visual analysis (Luo & Zhou, 2015).

This study highlighted visual factors that influenced a mobile user's interaction when using such a device. A visual-content analysis was recommended as an appropriate method in communication-related (Ary, Jacob, & Razavieh, 2010) and visual representation-related studies (Bell, 2001). By exploring visual-related factors in mobile iconic communication, the results are expected to be beneficial for both mobile-application developers as well as mobile users.

CHAPTER II

LITERATURE REVIEW

Mobile Technology

Background

Mobile technology is one of the 21st century's manifestations. Mobile technology is an attractive technology that has been widely used for different purposes. Recently, mobile devices have become a tool that supports learning, performance, and personal uses. In context, designing for a mobile device has had and will continue to be immensely complex. Before the revolution of small-screen mobile devices, various screen sizes and dimensions were not in existence. However, in the past two decades, the era in which new devices have been sold in the market, there is an enormous variety in device screen sizes, dimensions, and shapes. Smart watches, for example, have taken us in a different direction in terms of the shape and size of a device's screen. These major changes in producing new types of devices raise the question of whether a mobile device differs from other types of devices.

What is Mobile Technology?

Mobile technology has the distinction of portability (Zamfiroiu, 2013). However, other distinctions characterize MT besides mobility. Wagner (2005) designated mobile technology by its form of device: cell phones and smart phones, PDAs (personal digital

assistants), MP3 players, portable game devices, handhelds, tablets (iPads and Kindles), and laptops.

However, these characterizations lead to whether or not laptops are considered mobile devices. According to numerous researchers in the field of MT (Bentley & Barrett, 2012; Katz & Aakhus, 2002; Traxler, 2007), laptops are separated from mobile technology since they have the same characteristics as PCs except for the mobility. Laptops are not application-based devices on par with mobile devices such as smartphones and tablets. As emphasized by Bentley and Barrett (2012), MTs are radically different from laptop experience wherein MTs require different design philosophies. Thus, laptops are not considered mobile devices due to their dissimilarity to characterized mobile devices.

Characteristics of Mobile Devices

Ownership of mobile devices has increased significantly. Mobile phones and handheld electronic devices are one of the fastest-growing technologies in the market (Schlick, Ziefle, Park & Luczak, 2012), requiring more efficient and effective visual designs. In terms of mobile design, it has been argued whether a mobile device has its own unique design philosophy among other devices such as a PC. In his book *Programing the Mobile Web*, Firtman, (2013) specified a chapter titled, “*The Mobile Jungle*” wherein he mentioned the programing protocols used in a PC are the same as those used for a mobile device, which supported the fact that a mobile device is just a device that displays a piece of content. However, later in the chapter, he emphasized that screen size is the most obvious difference that differentiates the mobile device from other devices. Thus, the programing phase for a mobile device does not vary from other

devices but due to the screen size, designing principles for a mobile device's interface are obviously different.

One of the most significant characteristics of MT is the ease of portability. As reported by Zamfiroiu (2013), "A mobile device is a computer with reduced dimensions that is easy to be carried by the user anywhere, such as a mobile phones, smartphone, notepads, notebooks, laptops, [and] tablets" (p. 219). Mobile technology boasts exceptional innovations that make it exceptional and unique. For example, the short message service (SMS), multimedia messaging system (MMS), voice and video call, wireless fidelity function (WiFi), cellular data of 4G and LTE, Bluetooth, cameras, MP3 sound player and recorder, and touch screens are functionalities and innovations that distinguish mobile technology. Therefore, mobility is the major function that characterizes MT. For example, cell phones have become an important personal item that is carried all the time (Wagner, 2005). In summary, Hooper and Berkman (2011) highlighted the characteristics of mobile devices: small screen size, can be portable, wirelessly connected, interactive, and contextually aware. Accordingly, design philosophies and software platforms in MT differ from other types of technologies in several ways.

Challenges of Mobile Design

Based on what has been discussed above about the characteristics of mobile technology, it is obvious that MT designers must take into consideration additional designing procedures and techniques. In the literature focused on mobile design, a number of issues were listed as challenges in designing mobile interfaces. For example, Tidwell (2011) indicated, "When you design for a mobile platform, you face challenges

that you don't encounter when your user can be presumed to be sitting quietly in front of a large screen and keyboard" (p. 442). Tidwell listed six main challenges faced by mobile interface designers: (a) tiny screen size, (b) variable screen widths, (c) touch screen, (d) difficulty of typing text, (e) challenging physical environment, and (f) social influences and limited attention.

The size of the screen was a major consideration mentioned by literature in different disciplines that study mobile technology (e.g., computer science, graphics design, and interaction design). Small-screen size devices have become highly popular and are used worldwide, supporting the fact that they will continue to be the most accessible and usable devices for different purposes. In the past decade, smartphones and tablets have become one of the most important products on the market. For instance, sales of smartphone and tablets sales multiplied twice between the years 2014 and 2016 (Statistica, 2016).

The size of the screen is considered a major designing challenge as it influences the process of interface design, which requires designers to produce an appropriate design interface for such a device. Robbins (2006) indicated, "What looks good on a PC monitor may not work at all on the small screen" (p. 40). Moreover, Tidwell (2011) pointed out, "When you design for mobile platforms, you face challenges that you don't encounter when your user can be presumed to be sitting quietly in front of a large screen and keyboard" (p. 442).

How to Approach Mobile Design

Several recommendations addressed the issue of designing a mobile interface. One recommendation was to deeply analyze the user's needs and experiences. Tidwell

(2011) indicated that mobile users use the device for purposes like searching for information, social networking, and searching for surroundings. Accordingly, mobile developers must identify users' needs and then provide products to meet those needs.

Another recommendation was to use icon-based communication methods that help users interact in more efficient ways. Mobile devices are based on technology that contains tens of thousands of applications and features. These applications and features must be easily accessible by different users. Therefore, mobile developers have integrated icons to be representative of mobile applications and features. Use of icons has increased user performance and interaction (Luo & Zhou, 2015).

Because a variety of devices have become a critical challenge in interface design, several attempts have been made to produce one interface that can be appropriately displayed on any device. For example, Marcotte (2010) introduced a new term, *responsive web design* (RWD), which focuses on how one version of an interface can be appropriate for different types of devices. Wisniewski (2013) defined responsive design as

a set of tools, most of which you're probably already familiar with, and techniques, many of which you're probably not, that allow web designers to create a single website that responds to context. A site, when viewed on a desktop computer, will look and behave differently than that same site when viewed on a smartphone, which in turn will look and behave differently when viewed on a tablet. (p. 74)

The goal of RWD is to maximize the visual quality of the website's interface, regardless of the device displaying the content (Kim, 2013), by resizing the visual content based on the device being used (Wisniewski, 2013). In fact, the mobile-web becomes a crucial part of the web design (Kim, 2013), which make the process of designing visual and graphical components easier and difficult at the same time. It makes the job of the

designer easier by designing one visual edition that can fit any screen size and, at the same time, these visual components must follow the role of the PC's designing roles and mobile standers.

Summary

Mobility is considered the primary distinction of mobile technologies. However, in the manner of iconic communication, laptops are excluded from mobile technologies because they are not application-based devices. When designing for a mobile, the size of the screen is the most major challenge faced by mobile interface designers, which has led mobile developers to initiate iconic communication to promote interaction between the user and the device.

Interaction in Mobile Design

Background

The term "interaction" is constantly mentioned by researchers in fields such as computer science (Barthel, Kröner, & Hauptert, 2012), software engineering, graphic design, instructional design (Jacko, 2011), industrial design, etc. Interaction, in general, is defined as "a special kind of action that involves two or more entities and a set of reciprocities that effect changes to each entity" (Marchionini, 2008, p. 170). In mobile design, interaction is discussed when designing mobile interfaces. According to Huang (2009), interaction between the computer and its user occurs at the user's interface. Consequently, a number of theories, models, and designing approaches discussed in the literature of mobile design review the manner of interaction.

In general, design encompasses different fields and disciplines and each discipline has its own systematic approach based on its application and the use of design principles

(Adams, 2013). The term *interaction design* (ID) was used in different disciplines by researchers from various backgrounds (Huang, 2009). In their book *Interaction Design: Beyond Human-Computer Interaction*, Preece et al. (2002) described ID as “designing interactive products to support people in their everyday and working lives” (p. 7). Denning and Metcalfe (1997) described the design role as “the construction of the interspace in which people live, rather than an interface with which they interact” (p. 159), which is why we must understand how people adapt to new technologies (Denning & Metcalfe, 1997).

Interactive design advocates that designers provide a product whose interaction experience is easy, comfortable, and enjoyable (Preece et al., 2002). To ensure these goals are achieved, it is important to have a deeper understanding of what makes users fully interact with a device. Understanding users is a matter of concern since every discipline has a different evaluation angle. Thus, it has been recommended that people from different disciplines be involved in the procedure of analyzing the users (Preece et al., 2002), which would afford multiple views rather than a single one. In the research field of mobile technology, numerous theories and models have investigated the human computer interaction within the device.

Human-Computer Interaction

In their book *Psychology of Human-Computer Interaction*, Card, Moran, and Newell (1983) introduced the theory of human-computer interaction (HCI) that illuminates the interaction between computers (machines) and its users (human). Human-computer interaction theory emphasizes that computer designers and developers must create a communication tool that is friendly, enjoyable, and easy to navigate in order to

meet users' needs and maximize its appeal (Card et al., 1983). Human-computer interaction focuses on two types of design: hardware and software. In mobile design, hardware is the shape of the device and its physical components (Denning & Metcalfe, 1997). On the other hand, software is the programming and interface-designing piece. According to Huang (2009), the interaction between the computer and its user occurs at the user's interface.

Because the concept of incorporating HCI into mobile design has been adopted by mobile technology (Lim, 2010), mobile-computer interaction has become a major concern of mobile technology research. For instance, in 1998, the Special Interest Group on Computer-Human Interaction and the Special Interest Group on Mobility of Systems, Users, Data and Computing initiated an annual conference entitled Conference of Human-Computer Interaction with Mobile Device (MobileHCI; Johnson, 1998), which was sponsored by well-respected technology brands such as Google, Microsoft, and TobiiPro. Since then, they have been discussing issues concerning computer-human interaction on mobile devices. Today, MobileHCI focuses on topics related to mobile design in terms of mobile interaction. Consequently, there have been few attempts to use a new term called mobile-human interaction (MHI), a sub-theory of computer-human interface (CHI). In its concept, mobile-human interaction emphasizes factors that influence the interaction between the mobile user and the mobile device.

A number of studies (Dunlop & Brewster, 2002; Huang, 2009) have highlighted challenges and limitations of HCI in mobile design. One of these challenges was the variety of mobile users. When Huang (2009) reviewed the challenges of HCI with mobile devices in both software and hardware designs, he stated that it is highly

challenging for designers to produce a mobile interface that is usable for different varieties of users. Moreover, owing to the size of the device, one of the most significant challenges in HCI with mobile devices is the size of screen compared with regular screen-sized devices like a PC. Obviously, interface layouts, navigations, browsers, images, and icons would appear differently on these types of devices (Huang, 2009). In addition, Dunlop and Brewster (2002) highlighted a number challenges for CHI in mobile design:

1. To design for a variety of users who have different cultures and backgrounds.
2. To produce a design that contains a variety of context information in one tiny display.
3. To design a multi-task function in the mobile device due to the limited size and built-in inputs and outputs.

Thus, to answer the question of what possible solutions could designers and technical experts follow to increase the interaction plot and provide an appealing user experience, one suggestion was mentioned by Huang (2009)--to learn more about the users:

In order to design usable, useful, and enjoyable systems, interface designers and technical practitioners should always take into account the people who are going to use the interactive products, where the products are going to be used, what may help users with the way they are doing things, and what may provide quality user experiences. (p. 240)

Moreover, another lens of reviewing the challenges of human-computer interaction in mobile technology was found under the concept of Human-Information Interaction, which is an extension of the concept of HCI and HMI. In the literature of HCI,

information presented by such devices is considered a major factor that affects the level of interaction between the user and the device. The concept of human information interaction (HII) was inspired from human-computer interaction (Morville, 2005).

Human-Information Interaction

As mentioned earlier, interaction is defined as “a special kind of action that involves two or more entities and a set of reciprocities that effect changes to each entity” (Marchionini, 2008, p. 170). Nahum Gershon (as cited by Morville, 2005) coined the term *human information interaction* (HII) as “how human beings interact with, relate to, and process information regardless of the medium connecting the two” (p. 58). The aim of HII is to increase the interaction between the user and the interface, taking into account the way information is presented. In other words, in order to promote the interaction between the computer and the user, it is also important to review how information is presented and displayed in the device. This is why HCI researchers have focused on interaction with information rather than computers (Marchionini, 2008). More specifically, information designers must take a more ecological view of the information, which aims to develop new perspectives in the real world of research and practice (Marchionini, 2008).

Interacting with information in mobile technology is also a major concern. Owing to the challenges discussed earlier such as screen size, variety of users, and functional boundaries, designing information for such devices is not an easy task. Displayed information stimulates users to interact with the device on multiple levels within a short period of time. For instance, throughout the interaction, “the user is required to identify displayed information, select responses based on the displayed

information, and execute those responses” (Proctor & Vu, 2012, p. 22). Accordingly, these different levels of intersections require further attention to the interface’s information and contents in order to promote the interaction parameter.

Mobile Interaction Design

Since the 1990s, when mobile devices were taking their place in the field of research, software engineers, computer scientists, and instructional and industrial technologists have used the term *mobile interaction design* (MID). Based on the fact that the idea of interaction design is to produce “interactive products to support people in their everyday and working lives” (Preece et al., 2002, p. 7), MID focuses on producing hardware and software products that maximize the interaction between users and the portable devices they carry anytime anywhere (Kjeldskov, 2013). The fundamental concept of MID is knowledge of users' tasks is the key to designing an effective interface (Ngo & Byrne, 2001). According to a number of MID researchers (e.g., Bentley & Barrett, 2012; Huang, 2009; Preece et al., 2002), it is important to involve multiple disciplines in the process of understanding users to maximize their interaction with the mobile device.

Mobile interaction theorists and researchers from different fields and disciplines have pointed out some boundaries associated with MID (Kjeldskov, 2013). For instance, since MID focuses in most cases on the interface design (Bentley & Barrett, 2012), the majority of interaction challenges in mobile design occur during the process of developing software applications (Kjeldskov, 2013). For example, due to the size of the screen, it is more challenging for the developer and the designer to meet interaction standards that contrast with large-sized devices (Bentley & Barrett, 2012), requiring

designers to ensure the interaction mission has been met. According to Preece et al., (2002), “The way an interface is designed can greatly affect how well people can perceive, attend, learn, and remember how to carry out their tasks” (p. 104).

Accordingly, mobile interface is of critical concern by MID researchers in terms of user-interaction.

Interface Design Versus Human-Computer Interaction

Interface design plays an important role in human-computer interaction.

According to Cheon and Grant (2009), hardware and software interface design is an area of research interest by the HCI research group. Regarding this matter of mobile interface design, the interaction between the computer and its user occurs at the user’s interface (Huang, 2009). For instance, an interface’s visual aesthetics positively promote a user’s usability, satisfaction, and experience (Xu, 2013). In iconic communication particularly, Michalski, Grobelny, and Karwowski (2006) investigated the effects of graphical interface characteristics on HCI and found out the icon design had an influence on the HCI task commitment being more efficient. Additionally, Luo and Zhou (2015) found a mobile icon’s background shape and figure/background area ratio had a strong effect on user performance and preference.

Interface Design Versus Usability

Usability of the product is the most important factor that leads the product to be successful. As described by Shackel (2009), instead of as a mere peripheral, designers must take into consideration the user as the center of the computer. In this context, Shackel defined usability as “the capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support,

to fulfill the specified range of tasks, within the specified range of environmental scenarios” (p. 340).

It has been argued whether an interface visual design has an impact on usability. In terms of an interface’s aesthetics, an interface’s visual aesthetics positively promote a user’s usability, satisfaction, and experience (Xu, 2013). Tuch, Roth, Hornbaek, Opwis, and Bargas-Avila (2012) examined the impact of interface aesthetics on perceived usability and concluded an interface’s aesthetics did not affect perceived usability. At the same time, the study’s subjects were frustrated by the low usability and lowered their aesthetics ratings.

Sonderegger and Sauer (2010) assessed the effects of product aesthetics employing a mobile phone simulation where participants were asked to complete different tasks through two interfaces--highly appealing vs. not appealing. The result of the study confirmed that highly appealing interfaces promoted usability. On the other hand, low appealing interfaces negatively affected usability. The study also concluded the visual aesthetics of the phone positively maximized users’ performance by reducing the time of task completions.

Moreover, Lee and Koubek (2010) examined perceived usability and aesthetics before and after the actual use to understand the relationship between usability, aesthetics, and effect in HCI. By using different simulated systems with multiple levels of usability and aesthetics, the results concluded that before the actual use, a significant effect existed among the different levels of aesthetics and there was a slight effect across different levels of usability. However, after the actual use, the results concluded there was a significant effect across the different levels of both usability and aesthetics, which

emphasized the importance of both perceived usability and perceived aesthetics being considered in interface design.

Summary

Mobile developers' primary concern is to maximize the interaction between the user and the device. Interactive designers support producing a technology that is easy, comfortable, and enjoyable (Preece et al., 2002). In summary, human-computer interaction, human-information interaction, mobile interaction design, and, and interface design share the same goal--to maximize the interaction between users and their devices. However, each of these fields and disciplines provides different design suggestions and roles to meet the main goal of promoting the interaction. Therefore, some researchers (Preece et al., 2002) recommended that people from different disciplines be involved in the process of analyzing the users and what makes them interact efficiently with their devices.

Visual Communication in Mobile Design

Background

A question that might be asked is: why is it important to communicate visually? According to Jensen (1996), 90% of information received by a normal person is visual. Moreover, cognitive theorists believe human brains interact visually more effectively than verbally (Meier, 2000). In the 21st century with the innovations of portable technologies, the need for being visual literate has become very important. Furthermore, according to Lohr (2007), being visual literate is a convenient way to reduce the cognitive complexity of surrounded visual information where a person's daily life is full of visual information that must be identified and given a meaning.

Knowing the basic concepts of visual communication is important in many fields and disciplines. According to Lohr (2007), increased visual literacy automatically improves the quality of material and content designed for different purposes. In learning, for example, Meier (2000) studied the effects of visual components in learning. Regardless of age, ethnicity, gender, or preferred learning style, Meier's study concluded that people who supplemented their learning with visual components had on average a 12% better immediate recall than those who did not use visual components and a 26% better rate of retention in long-term memory.

Visual communication is a term discussed in multiple disciplines, eras, and concerns. According to Baca and Braden (1990), the term visual communication or visual literacy has been subjective according to individuals' perspectives, backgrounds, and professional concerns. Moreover, Hortin (1980) stated the field of visual communication is a confluence of different fields such as psychology, art, philosophy, and even more. Moriarty and Barbatsis (2005) underlined visual communication nodes that included visual intelligence, visual literacy, graphic design, visualization, visual culture, and professional performance (photography, film, video, internet, etc.).

Additionally, Braden (1996) reviewed how the term visual literacy was stated in six books from different disciplines that included the term "visual literacy" in its titles; he discovered each of the definitions differed from the others. For example, one of these books focused on visual communication because of the discipline of the author, another described visuals as graphics and illustrations, while yet another determined visual literacy as visual arts, and so on (Braden, 1996).

Many researchers (Braden, 1996; Case-Gant, 1973; Sinatra, 1988; Griffin & Whiteside, 1984) have attempted to determine the proper description of visual communication and to highlight its natural concepts. In fact, the term visual literacy was coined the first time by John Debes (as cited in Brill, Dohun, & Branch, 2007) as “a group of vision-competencies that a human being can develop by seeing and at the same time having and integrating other sensory experiences” (p. 49). Similarly, Hortin (as cited in Braden, 1996) attempted to define visual literacy as “the ability to understand and use images, including the ability to think, learn, and express oneself in terms of images” (p. 492). Baca (as cited in Braden, 1996) further revised Hortin’s definition and defined visual communication as “the use of visuals for the purposes of communication, thinking, learning, constructing meaning, creative expression, and aesthetic enjoyment” (p. 493). Also, Brill et al. (2007) concluded that visual communication as a concept “illustrates the many dimensions of visual literacy that can be learned, used, and integrated simultaneously into a message” (p. 51). One of the most recent definitions of visual communication is the Visual Literacy Competency Standards for Higher Education (ACRL; Beatty, 2013): “a set of abilities that enables an individual to effectively find, interpret, evaluate, use, and create images and visual media” (p. 34).

Variations found in defining visual communication seem natural because the primary differences among these definitions are minor and unessential. Because technologies change every day, many fields and disciplines’ terms and definitions used to describe their concepts may become unusable due to the need to update terms and definitions from one decade to another. According to Reiser (2011), terms and definitions can be restructured regarding to changes in innovations and practices of

individuals in the field where visual content has been extended from a historical epigraph to modern use. According to Argerinou and Pettersson (2011), the concept of visual communication has “varied from very narrow to very broad explanations of greater or lesser complexity” (p. 6). In short, there could be potential for having a group of definitions for visual communication, rather than just the one, because together they might elucidate the concept.

Visual Communication

Since the term visual communication first appeared in research studies, no substantial theories have been developed further regarding the term (Argerinou & Pettersson, 2011). However, in the field of visual communication, researchers have primarily focused on its applications and how it can be taught (Hortin, as cited by Argerinou & Pettersson, 2011) rather than focusing on an overall concept or theory to define the term. Regarding this matter, Griffin and Whiteside (as cited in Argerinou & Pettersson, 2011) argued that visual communication theories should “stimulate practical applications” and suggested it should be approached from three different perspectives:

(1) a theoretical perspective which incorporates the philosophical, psychological, and physiological aspects, (2) a visual language perspective which incorporates a receiver-oriented approach committed to helping people become visually literate through the effective deliverance of visual stimuli, and (3) a presentational perspective which incorporates a presenter-oriented approach and the improvement of communication processes through the design of visual stimuli. (p. 3)

Visual communication researchers have indicated visual communication is a combination of various distinct theories. For example, Johnson (as cited in Braden, 1996) characterized visual literacy as confluences of theories that are “brought together to

form a vague, unorganized concept that tries to explain the notion of visual sequencing” (p. 450).

A number of theories (cognitive information processing theory, dual coding theory, and multimedia learning theory) are involved in understanding and applying the concept of visual communication. However, since the concept of visual communication is to understand, use, and communicate visually in an effective manner (Braden, 1996), Lohr and Gall (2008) suggested the theories that focus on how knowledge is gained and received should be taken into consideration in visual communication, particularly those theories based in the cognitive sciences. Additionally, they argued learning theories help to contribute to our understanding of how visuals might be presented. Therefore, discussion about the theoretical foundation of visual communication is structured by the most frequent cognitive theories that answer the question of how visuals can be transferred, received, and processed by humans.

An example of cognitive theories that investigate how human process visuals is dual-coding theory (DCT), which provides an explanation for how the human brain deals with verbal and visual information. One of the primary principles of DCT is the human brain is divided into two systems: verbal memory--which deals with language systems and image memory--which includes non-verbal information (Beatty, 2013). Also, DCT psychologists believe the visual or image system in the brain is much larger than the verbal system (Meier, 2000). According to DCT, it is beneficial to present verbal language along with visual images. Thus, a number of suggestions have been provided by experts in the field of visual communication to design effective visual communication. For example, it is more effective to combine visual and non-visual “verbal” information

together in a single content. Additionally, Lohr and Gall (2008) recommended “presenting a combination of visual and verbal information is likely to increase the chances of recognition and recall, due to the strengthened associations afforded by dual coding” (p. 88).

In the context of mobile icon design, DCT theory does not provide a fully designed guideline due to the limitation of mobile technology in terms of supporting multi-tasking functionality. However, it underlines that a human’s visual system in the brain is much larger than the verbal system, which motivates mobile application designers to produce simple, text-free imagery icons in mobile application design.

Another theory that implies the process of visual communication is multimedia learning theory (MLT). Multimedia learning theory demonstrates that auditory and visual are two separate information-processing channels that are limited in capacity (Mayer, 2001, as cited in Beatty, 2013). As an illustration, Beatty (2013) suggested that in cases where verbal and visual information are presented together, interface users “must actively select discovery tools, organize keywords into a search statement, and integrate visual materials with verbal information” (p. 36). In terms of mobile application icon design, which is similar to DCT, due to the limitation in mobile functionality, mobile technology does not support multimedia-based iconic communication.

Nevertheless, in the matter of mobile iconic communication, cognitive information theory was the most adequate theoretical framework for this study as it interprets how human recognize and receive information-- whether it is visual or verbal.

Cognitive Information Processing Theory

Cognitive information processing theory, the framework for this study, is one of the most relevant theories that portrays how new information is transferred through memory is information processing theory (IPT). In fact, the information processing approach in psychology is mostly paired with the fields of cognitive psychology, human factors, and human engineering (Proctor & Vu, 2012). According to information processing theorists, humans learn and process information in the same way as computers (Driscoll, 2005). Information processing theory psychologists believe new information goes through three phases in the human brain: sensory memory, working memory, and long term memory. These three phases can also be called input, processing, and output. Sensory memory, the first stage in processing new information, is connected with the five senses (Driscoll, 2005). According to Jensen (1996), 90% of information a normal person receives is visual information. Moreover, Meier (2000) suggests “the human brain is basically an image processor, not a word processor” (p. 160), which emphasizes how visual communication is important and how it works.

Additionally, IPT theorists believe humans process new information the way the information was perceived (Harasim, 2012). Thus, they suggested an audience’s attention must be directed with specific rather than undirected visual messages. Information processing theorists also believe learners’ prior knowledge with regard to the subject is very important as it enables them to become fully connected with the new knowledge. Therefore, when designing visual materials, an individual’s prior knowledge must be considered so designers can anticipate how visual effects will be perceived by the audience created by the meanings learners give to people, places, things, and ideas

based on their long-term memories. Moreover, for an effective visual interface design, ITP theorists suggest information must be easily retrievable so audiences are enabled to recall information from their long-term memory (Driscoll, 2011). Finally, according to IPT, environment plays an important role in learning (Driscoll, 2011).

Changes of elements and principals of design that are influenced by size of the screen have their impact on information processing as well (Schlick et al., 2012). Proctor and Vu (2012) suggested designing and evaluating mobile interfaces must be associated with an information processing approach in terms of promoting the interaction.

Moreover, information processing can highlight issues related to HCI. Proctor and Vu noted,

Within HCI, human information-processing analyses are used in two ways. First, empirical studies evaluate the information-processing requirements of various tasks in which a human uses a computer. Second, computational models are developed which are intended to characterize human information processing when interacting with computers, and predict human performance with alternative interfaces. (p. 22)

Thus, during the process of designing mobile interfaces, IPT perspectives can be summarized as follows: (a) the design method must be directed to the audience's attention, (b) mobile device user's prior knowledge must be identified and connected to the new content, (c) visual information must be simply retrieved to enable users to recall information, and (d) the user's environment must be taken into consideration.

Elements and Principles of Design

Visual communication, which is a "form of communication that is not verbal" (Lohr, 2007, p. 13), has a number of elements and components. In general, design is encompassed in different fields and disciplines and each discipline has its own systematic approach based on its application and the use of design principles (Adams, 2013). In the

context of mobile design, visual elements--the prepared form of visual communication (Saunders, 1994) and a variety of visual materials--were listed by researchers in the field of visual communication. For instance, Sabau and Sabau, (2008) indicated elements of visuals included points, lines, shapes, masses, spaces, motions, lights, colors, and textures. Moreover, Braden (1996) introduced five visual categories that have been investigated by visual communication research and study: semiotics and film/video conventions, signs, symbols, icons, images and illustrations, multi-images, and graphic representation.

In the context of elements of design similarity, graphics are considered a key method that focuses on how design elements illustrate a visible and usable interface. Graphics include symbols, maps, graphs, diagrams illustrations, rendered pictures, models, composite graphics, and photographs (Lohr, 2007). Regardless of the design principle, this research follows the following definition of visual elements and design principles in mobile interface design: “the degree to which a person believes that elements of design have been employed in the overall design” (Lin, 2013, p. 1113).

The term “principles of design” was mentioned in different fields and disciplines (e.g., visual arts, computer graphics, architecture). The principles of design listed in the literature of these different fields were similar but not the same due to each field’s various applications (Cheon & Grant, 2009). For example, art education research has five main design principles: rhythm, emphasis, harmony, balance, and unity (Johnson, 1995). However, an architecture study by Adams (2013), which explored an architecture educator’s perceptions about principles and elements of interior design, showed the main design principles were harmony, unity, balance, hierarchy, and emphasis.

In the field of mobile interface design, most researchers (Altaboli & Lin, 2011; Bauerly & Liu, 2006, 2008; Ngo & Byrne, 2001) who investigated the principles of design were focused on the aesthetics phase of designing an interface--aesthetics and interface were consistently associated sequentially. Ngo and Byrne (2001) explored an aesthetic evaluation model to assess screen formats. They concluded the most effective three elements in the screen interface were balance, unity, and sequence. Furthermore, based on Ngo and Byrne's study, Altaboli and Lin (2011) used the three elements of design, balance, unity, and sequence to investigate effects of the interface elements on design aesthetics. The result of the study confirmed there were significant effects on interface aesthetics utilizing these three elements as well as the interactions among them.

Bauerly and Liu (2006) examined the effects of symmetry, balance, and quantity of construction elements on interface aesthetic judgments. They used three experimental methods: (a) to develop systematic 30 black and white geometric images to validate the computational aesthetic, (b) to ask participants to estimate the standard number of the elements, and (c) to ask the participants to order a list of images based on their aesthetic appeal. The study concluded there was a positive relationship between high symmetric images and aesthetic appeal. Moreover, there was a negative relationship between number of grouping and user's appeal-- user appeal increased in interfaces that had less numbers of groupings. Additionally, follow-up research by Bauerly and Liu (2008) investigated the effects of symmetry and number of compositional elements on interface and design aesthetics. Their results showed symmetry was an important element that increased the user's appeal and the aesthetics appeal rating was influenced by the quantity of compositional elements. These previous studies investigated elements and

principles of design regardless of how these were displayed. According to different sources (Robbins, 2006; Tidwell, 2011), due to the size of the screen, elements and principles of design do not appear the same way on large-screened devices. As mentioned by Schlick et al. (2012), mobile devices differ due to the physical dimensions, color, resolution, contrast, luminance, and touch/stylus sensitivity (p. 200).

Summary

Visual communication, a non-verbal form of communication (Lohr, 2007), is involved in different fields and disciplines such as psychology, art, philosophy, and even more (Hortin, 1980). The involvement of visual communication varies slightly from one field to another based on an individual's perspectives, background, and professional concerns (Baca & Braden, 1990). Visual communication nodes include visual intelligence, visual literacy, graphic design, visualization, visual culture, and professional performance (Moriarty & Barbatsis, 2005).

One of the most relevant theories that justifies how humans' brains perceive, process, and response to visuals components is cognitive information processing theory. In information processing theory, psychologists believe new information, including visuals, goes through three phases in the human brain: sensory memory, working memory, and long-term memory. In this context, visuals are elements of design and include points, lines, shapes, masses, spaces, motions, lights, colors, and textures; principles of design include harmony, unity, balance, hierarchy, and emphasis.

Icons in Mobile Technology

Background

Formerly, an icon was an image of a saint and other holy personage in Byzantine, Russian, and Greek Orthodox churches (Clarke, 2010). Humans have used and continue to use the icon as a communication method. Communicating via icons is a popular communication method humans have and continue to use. As Steinfatt (2009) stated, human communication occurs through the use of mutually familiar symbols. An icon can be defined as a small graphical metaphor (Benson et al., 2004) that “represents a single object or concept like a word rather than being worth a thousand words like a picture” (Huang et al., 2015, p. 702).

The Importance of the Icon

Numerous sources (Benson et al., 2004; Hooper & Berkman, 2011; Huang et al., 2015) concluded that mobile users interact via icons more efficiently than with text representations. The concept behind using icons as visual representations of mobile applications is to maximize the interaction between the device and the user. After the icon has been used frequently, one becomes accustomed to recognizing it easier than a text and are immediately reminded of the application it represents (Benson et al., 2004; Huang et al., 2015).

Moreover, due to the insufficient screen size, an icon representation is more appropriate to display a large number of applications on a single screen utilizing a mobile interface (Benson et al., 2004). For example, the iPhone 6 has a 4.7” screen size and can display 28 items on one single page. Also, the 1.5” Apple watch screen displays 17 items on the home screen. Without the adoption of iconic communication, small screen devices

would not be as efficient as they are now. Conclusively, iconic communication helps low-literacy users visually communicate rather than being forced to read traditional texts.

Design Guidelines for a Mobile Icon

The question has been asked: what is an interactive, well-designed icon and how does it appear on a small touch-based mobile device. In fact, there are several recommendations for interactive icon design. For example, Benson et al. (2004) indicated a well-design icon is one that reflects its application content and refers to the item it represents. Additionally, Hooper and Berkman (2011) pointed out,

Well-designed icons serve as an easily understandable, easily recalled representation of an action or target destination, such as a website or application. They are particularly suitable for Home & Idle Screens, when used as full grids of icons and as small lists of key applications on a more general-purpose idle screen. (p. 214)

Moreover, *iOS Human Interface Guidelines* (Apple, 2015) list the following recommendations for designing a mobile application icon:

1. Enlist a professional graphic designer's feedback.
2. Use visuals that are easily recognized.
3. Embrace simplicity and avoid complexity.
4. Design an abstracted icon that is reflective of the app's nature and content.
5. Create graphical icons that are visible on a variety of backgrounds.

Furthermore, Barnard (2009) made some important suggestions for designing efficient and unique mobile icons. First, create the icon so its focal point is prominent. Second, keep the icon as simple as possible--free of text and photographs. Moreover, design icons that catch users' attention by adding visual senses that inspire humor and

enjoyment. These suggestions make an application's icon more memorable among the large number of available apps.

A functionally suggestive icon has been recommended when designing effective mobile icons. According to Heim (2008), understanding the relationship between the icon's visual components and its functionality helps users recognize the app by its icon.

Benson et al. (2004) stated,

Icons should be suggestive of the functionality with which they are associated. The best icon will suggest to the user the primary purpose of the program or operation without having to read accompanying text. Users recognize functionally suggestive icons more rapidly than other forms because they directly associate with a physical object or action. (p. 123)

Owing to text-free mobile iconic communication interfaces, icons should contain visual representations of the application's actual content. For instance, calling-tool applications should include graphics or symbols of phones that associate the icon to its natural function. Similarly, realistic-object icons are easier to recognize and understood by the user rather than abstracted ones. For instance, concrete icons are the most easy to remember and recognize; they are followed by abstract icons, which require thinking by the recipient (Lodding (1983). Arbitrary icons are ones that take time to be understood and recognized because of the imagination this type of icon requires of the recipient.

Individual Differences When Recognizing a Mobile Icon

One of the challenges of mobile interface design is the variety of users (Huang, 2009). Mobile developers create one interface for all types of users. In the matter of interface and icon design, it is important to consider individual differences in cognitive abilities (Holmberg & Gustafsson, 1993). In this regard, several studies have examined individual differences in recognizing mobile icons. Chung, Chau, Hsu, and Lee (2007)

assessed the effects of gender culture on mobile icon recognition in three types of icons: concrete, abstract, and arbitrary. They used two different methods to investigate the gender differences in icon recognition: a content analysis of the three types of icons and two questionnaires that included five concrete icons, five abstract icons, and five arbitrary icons. The study concluded there was no significant difference in concrete and arbitrary icon recognition across gender. However, females performed better in recognizing abstract icons.

Pappachan and Ziefle (2008) investigated cultural impact on the comprehensibility of icons in mobile computer interaction between two different cultures-- Indian and German. The Indian and German participants were shown a number of icons and then were asked to interpret each icon. The result showed that regardless of the user's cultural background, the more detailed icons were interpreted more readily in both cultures. In other words, no significant difference was found across cultural backgrounds.

However, significant differences were found between adults and older adults (65+) in mobile iconic communication. Leung, McGrenere, and Graf (2011) compared usability problems between old (65+) and young adults utilizing existing mobile graphical icons. They used two different methods: (a) a qualitative exploration to observe how young and old users interacted and identified the icons, and (b) a follow-up experiment to understand the effects of an icon's type between the two age groups. The qualitative results showed that older mobile users had more difficulty with unfamiliar mobile icons than did younger users. Similarly, the experimental results concluded young users performed better than older adults on abstract icons and on ones that were

not meaning-directed. Also, both older adults and younger had difficulty interacting and understanding unlabeled icons.

Summary

Communicating via icons is a popular communication method humans have and continue to use. In terms of mobile interaction design, due to the size of the screen, iconic communication has been successfully used in mobile technologies as the primary communication method. Numerous sources (Benson et al., 2004; Hooper & Berkman, 2011; Huang et al., 2015) concluded that mobile users interact via icons more efficiently than with text representations. Individual differences in utilizing iconic communication were investigated over time, particularly with regard to mobile technology. It has been concluded that there are no critical differences in icon recognition across variables related to gender, background, and age.

Conclusion

Gaps in the literature concerning mobile iconic communication and icon design were identified. First, in the fields of computer science, software engineering, and HCI, research studies investigated the interaction that accounted for usability of the product as a whole regardless of how the visual interface had been designed. Second, research studies (Marchionini, 2008; Proctor & Vu, 2012) that investigated interface-interaction focused on how the interface's information was organized and presented regardless of the interface's visual values. In other words, they focused on "what" contents were presented rather than on "how" contents were presented. Moreover, many research studies (Altaboli & Lin, 2011; Bauerly & Liu, 2006, 2008; Ngo & Byrne, 2001) that

evaluated the interface using a visual arts scale distanced themselves from evaluating the substance of the interaction.

This identified gap was somewhat covered and discussed in the literature. For example, several studies (Holmberg & Gustafsson, 1993; Lodding, 1983) investigated similar issues related to interface and icon design for PCs but not for mobile screens. Also, studies that reviewed the issue of interaction in mobile-interface design utilizing hardware and software scales did not cover visual elements and principles of design. Yet, to the researcher's knowledge, no research or study in existence has reviewed a mobile-interface design in the adoption of HCI using the scale of visual content analysis to evaluate visual elements and principles of design and examine the influence of the mobile's icon regarding interaction and communication.

Moreover, none of the current literature used the approach of content analysis as a method that led to discover the current use of the elements and principles of design in the real world of mobile device interfaces. This type of analysis helps to recognize factors in which the elements and principles of design appear. Ary et al. (2010) indicated content analysis is a "research method applied to written or visual materials for the purpose of identifying specified characteristics of the material" (p. 457). Also, visually analyzing the elements and principles of design in a mobile application's icon is a better approach than examining individual variables (Haag & Snetsinger, 1993). Particularly, incorporating human cognition roles in visual processing helps elucidate the real nature of visual design (Carroll, 1997).

CHAPTER III

METHODOLOGY

The Purpose

The purpose of this study was to explore mobile icons' visual-related factors that affected a user's interaction. This study's outcomes are expected to be beneficial for applications developers, instructional designers, and mobile users. This exploratory, sequential, mixed methods design procedure took place in multiple phases based on the following sequence of data collection and analysis:

1. (a) Qualitative comprehensive visual analyses were conducted utilizing existing mobile icon elements and principles of design.
(b) Quantitative comprehensive visual analyses were conducted utilizing existing mobile icon elements and principles of design.
2. Mobile application users' perceptions toward mobile icon visual effects were examined in terms of user experience and interaction.
3. The three phases were combined and then compared to highlight hidden factors that could promote or diminish user interaction and how the elements and the principles of design were interconnected or disconnected with the users' perceptions (see Table 1).

Table 1

Sequence of Data Collection and Analysis

	Phase 1		Phase 2	Phase 3
(a)	(b)			
Visual analyses of elements and principles of design	Visual analyses of elements and principles of design	Users' perceptions about mobile icon design	Qualitative and quantitative visual analyses vs. users' perceptions	
Qualitative Visual Analysis	Quantitative Visual Analysis	Qualitative Interview	Qualitative Content Analysis	
“What” elements and principles were used	“How” do the elements and principles vary across different application categories	What visual factors are involve in using experience	How user's perception are related or not related to the visual analysis' outcomes	

Research Questions

This research sought meaningful answers to the following research questions:

- Q1 (a) What visual elements are used in a mobile application's icon and (b) how do these elements vary across different application categories?
- Q2 (a) What design principles are used in a mobile application's icon and (b) how do these principles vary across different application categories?
- Q3 What are mobile device users' perceptions about the visual design of mobile application icons?

Research Design

The goal of this research was to highlight hidden mobile icons' visual factors that influenced a mobile user's iconic communication. The process of data collection and the data analyses were structured through three main stages: (a) identify current characteristics and pattern design of existing icons in terms of what visual elements and principles had been used in a mobile application's icons, (b) compare mobile icons across

apps categories to underline how each category was different from the other regarding the elements and principles of design used, (c) explore users' perceptions about the elements and principles of design and account for how these elements and principles influenced the mobile application user's interaction, and (d) compare the outcomes of the visual analysis to the users' perceptions in terms of the iconic visual communication in mobile technology..

The stages of research were systematized by three main research approaches: a qualitative content analysis, a quantitative visual analysis, and an interview-based qualitative analysis. The qualitative content analysis constructed the visual landscape of existing mobile icons' elements and principles of design. Second, the quantitative content analysis compared existing mobile icons' elements and principles of design across different apps categories (music, news, lifestyle, social networking, sport, travel, etc.). Then, mobile-users' perceptions about visual-related factors that affect their interaction within the application were explored through a qualitative, interview-based, focus group approach. Lastly, the outcomes of the visual analysis were compared with the outcomes of the user interviews to explore whether there was a relationship between them. For example, in the Games category, most icons are cartoon-graphics based—would this fact be realized by mobile users?

Methodology Justification/Rationale

The idea behind conducting a mixed method design was to have a combination of quantitative and qualitative outcomes. As Creswell (2012) indicated, a “mixed methods research is a good design to use if you seek to build on the strengths of both quantitative and qualitative data” (p. 535). Qualitative content analyses are highly recommended in

visual and communication studies (Ary et al., 2010). According to Abrahamson (as cited in Cho & Lee, 2014), printed “and digital” media are commonly used in content analysis research (p. 3). This research highlighted the mobile application icons’ design characteristics and patterns. Thus, a visual-content inquiry was the most appropriate approach for such analysis. Ary et al. (2010) indicated content analysis is a “research method applied to written or visual materials for the purpose of identifying specified characteristics of the material” (p. 457). Content analysis is recommended for studies that characterize visual-related factors that affect a user’s communication and interaction among different variables. Altheide (1987) specified that content analysis is appropriate to “illustrate the usefulness of constant comparison for discovering emergent patterns, emphases, and themes” (p. 65).

Also, as Bell (2001) pointed out, utilizing a content analysis approach is appropriate for research questions about frequency, size, and order in a visual representation. Merriam (2009) indicated, “The units of measurement in this form of content analysis center on communication, especially the frequency and variety of messages, and the number of times a certain phrase or speech pattern is used” (p. 205). Ary et al. (2010) pointed out that “as the technological world changes and communication over the Internet becomes more prevalent, there are opportunities for content analysis to play a role in understanding and changing communication patterns” (p. 458). In using qualitative analysis with both the visuals and a focus group dialog, a depth of information should be available for interpretation to develop understanding about the characteristics of the application icons as well as the perceptions of users related to the visuals. Quantitative analysis was included to check the relationships

among the outcomes of the visual content analysis. This provided a depth of clarity to the findings and explored any statistical significance related to the data.

An exploratory, sequential, mixed methods design was recommended in this type of research where qualitative outcomes would lead to a quantitative analysis. Mixed methods researchers include a justification or rationale for the use of both quantitative and qualitative data (Creswell, 2012). One justification was collecting quantitative data in a second phase is important to test the qualitative explorations of the first phase of the study (i.e., exploratory design; Creswell, 2012). Thus, due to the type of this research problem and questions, this qualitative research was supported by secondary quantitative outcomes.

Theoretical Framework

A theoretical framework--which is defined as the “system of concepts, assumptions, expectations, beliefs, and theories that supports and inform your research” --helps the researcher justify his/her research (Maxwell, 2013, p. 39). Merriam (2009) suggested it is reasonable to identify the theoretical framework of a research study based on its discipline and related literature that investigated similar issues to the one being studied. The theoretical framework of this study was identified based on both the researcher’s disciplinary and related literature.

Owing to the goal of this research study, which was to explore the visual-related factors involved in mobile iconic communication, the theory of cognitive information processing (IPT) was identified as the grounded framework for this study. Proctor and Vu (2012) indicated human cognitive psychology, human factors, and human engineering are mostly associated with the theory of cognitive information processing. Moreover,

iconic communication goes through three phases of IPT: input, processing, and output (Driscoll, 2005). In other words, information-processing theorists believe there is a relationship between the way information is presented and the way the audience responds to such information (Harasim, 2012). In the context of iconic communication and visual design in mobile devices, Schlick et al. (2012) pointed out the size of the screen has an impact on information processing. Thus, how iconic communication is accessed (input), processed (processing), and responded to (output) by mobile application users was investigated.

Method

A mixed method design was utilized in this study. It was assumed combining quantitative and qualitative methods in a single study would allow a deeper understanding of the research problem rather than a single method (Creswell, 2012). As mentioned earlier, this study utilized mixed qualitative and quantitative approaches where the qualitative phase provided the themes, categories, or variables for the quantitative phase. Therefore, this study followed an exploratory, sequential, mixed methods design. Creswell (2012) pointed out that this type of exploratory, sequential, mixed methods design is used when quantitative factors are derived from a qualitative analysis.

Samples

This study involved content mobile application icon samples and mobile user participants.

Content mobile application icon samples. Various mobile application icons that exist in the Apple App Store were selected from different categories. The decision to select applications from the App Store was justified as they are highly standardized by

Apple and contain the largest number of applications available as compared to Google Play, which has less stringent standards for publishing an application. The app categories targeted in this research were News, Sports, Travel, Finance, Education, and Games. From each app category, the most popular top-20 apps were selected. The concept behind this selection procedure was the top-rated apps are more likely to have well-designed icons and provide better representations of the designing trends and patterns of the category.

Mobile user participants. Human participants were a selection of mobile users who would share their experiences and perceptions about designated icons. The study recruited 10 participants who were asked questions related to visual-related factors that influenced their interaction when using mobile devices. As mentioned in Chapter II, there were no differences in icon recognition among cultural backgrounds (Pappachan & Ziefle, 2008) and gender (Chung et al., 2007). To exclude age differences in icon recognition reported by Leung et al. (2011), participants in this study were 10 college students from 18- to 40-years-old selected through a convenience sampling method.

Study Characteristics

As a mixed method study, two separate approaches were utilized to work with the data. The qualitative method analyzed for characteristics. The quantitative analysis worked with dependent and independent variables.

Qualitative characteristics. Visual design was used as the lens by which to understand the data. The specific elements of design included line, shape, form, color, texture, and space; and the principles of design included pattern, contrast, emphasis, balance, and harmony.

Quantitative variables. Dependent variables were the elements of design (line, shape, form, color, texture, and space) and the principles of design (pattern, contrast, emphasis, balance, and harmony). Independent variables were the apps categories (News, Sports, Travel, Finance, Education, and Games).

Data Collection

Owing to the nature of this research--a content-based analysis that reviewed a sample of existed mobile icons, the process of icon selection take place as follows. Initially, 20 of the most popular mobile application icons from each app category (see Appendix A) were selected (20 icons x 7 categories). Because the top 20 applications change frequently, the date of selection was documented. To have an accurate representation of each app category, the most popular icons were ones having the highest number of downloads as well as the highest rated by users. These icons were selected from the Apple App Store only because Apple is more precise in terms of accepting applications published in their app store.

The secondary type of data was the mobile application users' perceptions. This type of data was collected from the participants through a focus group-based discussion. The participants were mobile application users who were college students between 18- and 40-years-old. They were asked questions regarding their mobile app experience and the role of icons in terms of how the elements of design and principles influenced their experience. Data obtained from the focus group were contrasted with data from the visual analysis to determine whether users were or were not careless about the visual factors of icon design.

Questions asked during the interview (see Appendix B) addressed issues related to user interaction regarding visual communication. As discussed previously, interaction design focused on three main components: easy, enjoyable, and appealing. Therefore, the interview was structured to ensure each of the three components was met. Questions discussed how the icon's elements and principles of design influenced the ease in finding, downloading, and using the mobile app. Similarly, the interview addressed how the icon's elements and principles of design influenced the user's experience as well as discovered unknown visual-related factors regarding the mobile application's icon communication.

Since the top ranked applications in the App Store are subject to change every day, a selection of the top 20 applications' icons from each app category was visually evaluated. At the time this research was developing, the top 20 apps from News, Sports, Travel, Social Networking, Education, Finance, and Games are listed below.

- News--Daily for Craigslist, Pocket Casts, Downcast, Conservative talk radio, etc.
- Sports--Pro football radio & live, Upward basketball coach, etc.
- Travel--Flight radar 24 – flight tracker, World phone, New York State snowmobiling, etc.)
- Finance-- Turbo Tax, Home budget, Investing.com, Spending tracker, etc.
- Education--Toca hair salon, Toca kitchen, Schoolly: scholarship search, Easy music, etc.)
- Games--Clash of Clans, Game of War, Candy Crush Saga, MADDEN NFL, etc.

Data Analysis

The goal of data analysis was to inspire a meaningful sense of the data collected (Merriam, 2009). Once collected, the data would be analyzed qualitatively and quantitatively through four different phases. As a sequential mixed method analysis, each of the phases was a prerequisite for the following phase.

Phase I(a) visually analyzed the selected sample of top 20 app icons for each category regarding what elements and principles were used. Merriam (2009) indicated a qualitative content analysis is widely adopted in studies that focus on communication. A qualitative content-visual analysis was used in this visual communication-based research. According to Cho and Lee (2014), deductive content analysis is recommended when prior knowledge about a research issue has been studied and well-founded. Therefore, the process of coding, categorizing, and theming was drawn from prior relevant literature such as the elements of design (line, shape, form, color, texture, and space) and the principles of design (pattern, contrast, emphasis, balance, and harmony). In short, this phase highlighted “what” elements and principles were used in the sampled icons.

After the elements and principles of design had been qualitatively highlighted in Phase I(a), Phase I(b) extended the analysis to “how” frequently and repeatedly these elements and principles were used across each app category (News, Sport, Travel, Social Networking, Education, Finance, and Games). Data analysis in this phase followed a quantitative content-visual process, which was appropriate for this kind of research problem. As Ary et al. (2010) emphasized, content analysis is recommended for studies that focus on human-visual communication. Moreover, Merriam (2009) pointed out content analysis is generally used as a quantitative approach. A frequency descriptive

quantitative content analysis was conducted in this phase by calculating the mean and the standard deviation of the elements and principles of design across each category. In this phase, the data were analyzed utilizing two different techniques--manually and digitally based on the visual item being analyzed. For example, the color of the icon was extracted through a tool in Photoshop that gave an accurate color code, which helped to decide whether the color was warm, normal, or cold.

The goal of Phase II was to investigate mobile application users' perceptions of a mobile icon's visual effects in terms of user experience and interaction. As mentioned previously, this phase's data were collected through interviewing participants who used mobile applications. They were asked questions regarding the icon's visual design and its impact on their experience and interaction. The interview audio was transcribed verbatim. Then, the data were organized according to the participants' responses. After that, the researcher arranged the themes according to the participants' responses to each interview question. This type of analysis helped the researcher seek meaningful conclusions as to whether the mobile users were careful or careless about the mobile application icons' visual communication factors.

The goal of Phase III was to investigate qualitatively whether there was a relationship between Phase I--the visual analysis and Phase II--the user's perceptions. Outcomes of Phase I and Phase II were discussed to decide whether the visual analysis of Phase I was similar or different than the user perceptions in Phase II. Merriam (2009) indicated all types of qualitative research employ a content analysis approach due to the content of interviews, observations, and artifacts. This type of analysis helped the researcher highlight hidden factors that could promote or diminish user interaction and

how the elements and the principles of design were interconnected or disconnected with the user's perceptions.

Trustworthiness

Credibility/Validity

To ensure the issues of credibility and trustworthiness of this study were addressed, the researcher took multiple aspects into consideration. As Willig (2013) pointed out, an inductive content analysis pays attention to the role of the researcher. Thus, to prevent issues associated with researcher bias, this research study was a deductive-based content analysis to reduce the voice of the researcher.

To ensure the internal validity of the data is plausible, member checking was utilized in this research. As Creswell (2012) stated, member checking is when "the researcher asks one or more participants in the study to check the accuracy of the account" (p. 259). The researcher re-contacted the participants to make sure their opinions were interpreted accurately. Member checking prevented the researcher's biases and personal impressions (Maxwell, 2013). Also, expert checking take place during the process of data collection and data analysis to ensure the researcher's biases were eliminated.

Furthermore, multiple approaches were used to collect and analyze the data-- qualitative vs. quantitative, user's perceptions vs. icon visual analysis, user interview vs. usability testing, and visual-content analysis vs. human responses and usability. The concept behind using a variety of data resources was to enhance the exactitude of the study's findings and results (Creswell, 2012).

Ethics

Ethical issues were cautiously encountered before, during, and after the process of data collection and analysis. The data were not collected until approval from the Institutional Review Board (IRB) is received (see Appendix C). Also, the 45 minute face-to-face participant interview did not contain any personal or sensitive information (see Appendix D for consent form). Upon collection, the data were secured and handled by no one except the researcher. Moreover, during the data analysis, the researcher used symbols instead of the participants' real names to conceal their personal identity and provide privacy.

Limitations and Delimitations

The ability to extract a meaning from the content is one of the unique characteristics of content-based analysis (Cho & Lee, 2014). However, it has been argued that induction is the primary process of analyzing content data wherein primary attention is paid to the role of the researcher (Willig, 2013) rather than the problem being examined. Another issue in content analysis is the risk of content-complexity (Cho & Lee, 2014) where some content and data cannot be coded or categorized easily. Moreover, time consumed in the process is an issue where the content, text, or graphic is not clear to participants (Cho & Lee, 2014).

In terms of the content samples of this study, the top ranked 20 application icons from six different app categories (News, Sport, Travel, Finance, Education, and Games) were selected as the visual analysis sample. Based on the researcher's point of view, the selected categories were the most popular in terms of number of downloads even though these rated applications were subject to change every day.

One of the study's limitations was some of the sample icons used in this study were logo-based icons. In other words, some of these applications were known even before the mobile technology. However, since this research highlighted design trends for different categories, the researcher decided to include them in the sample as long as these applications remained popular and could be used as representations for its app category. For example, in the News category, a number of popular application icons were visualized as a logo of a newspaper that existed a while ago. Thus, these icons featured how the news category application should be designed such as using a classic typeface.

In terms of the human sample, since there was no difference across gender, background, and educational level in icon recognition (Chung et al., 2007; Pappachan & Ziefle, 2008), the researcher's intent to interview 5-10 participants aged between 18-40 took into consideration the age range variations discussed in Chapter II since young users are faster in icon recognition than older users (Leung et al., 2011).

Relatively, since this research focused on mobile application icon, laptops were not counted as a mobile device. Although a laptop has the distinction of mobility, it is not an application-based device nor a touch-based device. A laptop has the same characteristics as a PC where design protocols and platforms are the same as a desktop computer (Bentley & Barrett, 2012).

Summary

The goal of this research was to highlight mobile icons' visual-related factors that influenced a mobile user's iconic communication and interaction. The process of data collection and the data analyses was structured through three main stages. First was to identify current design characteristics and patterns of existing icons in terms of what

visual elements and principles had been used in a mobile application's icons. The data collection and analysis stage was a qualitative visual-content analysis of selected samples of mobile icons. Second was to compare mobile icons across app categories to determine how each category was different from the other regarding the elements and principles of design used. This stage's data were collected and analyzed through a quantitative frequency descriptive analysis. Third was to explore users' perceptions about the elements and principles of design and account for how these elements and principles influenced the mobile application user's communication and interaction. Fourth was to compare the outcomes of the visual analyses to users' perceptions in terms of iconic visual communication in mobile technology.

CHAPTER IV

RESULTS

Introduction

This study highlighted visual-related factors that influence mobile users in the manner of iconic communication, usability, and interaction. Through the study of mobile application icons, the assigned research questions for this study were formulated to address three main issues: (a) the usage of design elements in mobile icons, (b) the usage of design principles in mobile icons, (c) and users' perceptions about the influence of an icon's visual design and their impact on mobile-user communication, usability, and interaction.

The following research questions guided this research study:

- Q1 (a) What visual elements are used in a mobile application's icon and (b) how do these elements vary across different application categories?
- Q2 (a) What design principles are used in a mobile application's icon, and (b) how do these principles vary across different application categories?
- Q3 What are mobile device users' perceptions about the visual design of mobile application icons?

To answer the research questions, three main data analyses were conducted: (a) qualitative content-visual analysis, (b) quantitative content-visual analysis, and qualitative-interview and analysis of mobile users' perceptions toward a mobile icon's visual design. The qualitative content-visual analysis answered the questions of "what"

and “how” elements and principles were used in the mobile icon. The quantitative content-visual analysis answered the questions of “how much” and “how frequently” those elements were used within each app category and across different app categories. The mobile users’ interviews answered the question of how mobile users were impacted by the elements and principles of design.

Phase I: Qualitative Visual Analysis

Research Question 1

The aim of this phase was to constitute the use of elements and principles of design in mobile application icon. The reason behind using a qualitative visual analysis was to identify the design’s implementation of existing icons in the app store. Ary et al. (2010) stated the purpose of conducting content analysis is to identify specified characteristics of the material being studied. Moreover, this phase is an introductory phase for the following analyses whose outcomes were used for the quantitative analysis and followed by mobile users’ perceptions.

Elements of design.

Shape. The design element of shape was well employed in mobile icons’ visual design. Regardless of the icon category, the analyzed contents showed that shape was employed in two main ways. First, all icons analysed used Apple’s standard shape, a rounded square (see Figure 1), as the icon design frame.

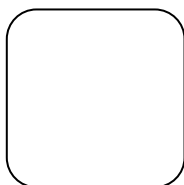


Figure 1. Apple’s standard shape for the application icon.

Second, some of the examined icons showed different implementations of the shape element, e.g., a circle, diamonds, or rectangle, inside the rounded square (see Figure 2).

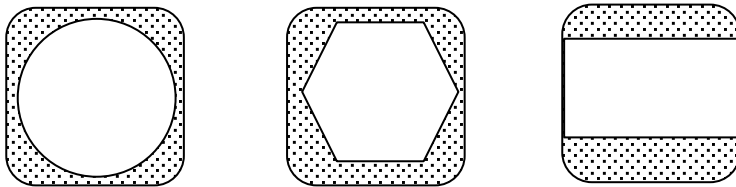


Figure 2. Examples of how different shapes are used in the application icon.

Also, when using another shape inside the rounded square, all of the icons used a unified color as a background of the icon. From the sample icons of this study, ABCmouse.com, Yousician, NCLEX RN Mastery, HomeBuddget, Chronicle, BUDGT, US Debt Clock, Overcast, OBD Fusion, WiFi Map Pro, and FlightTrack employed a circle shape inside the standard apple shape (see Figure 3).



Figure 3. Examples of how the circle shape was used in mobile application icons.

Similarly, from the sample icons, the Elevate app icon used a diamond or rhombus shape inside the standard shape (see Figure 4). An example of how a rectangle was used in MileBug's icon is provided in Figure 4.

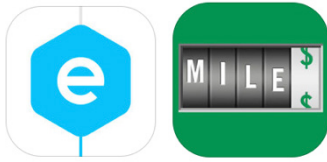


Figure 4. Example of how the rhombus and rectangle shapes are used in mobile application icons.

Form. Across the sample icons of this study, variations were witnessed in how the form element was used. Two dimensional-formed (2D) and three dimensional-formed (3D) icons were used among the different app categories. However, 2D-formed icons were the majority compared to 3D-formed app icons. Also, 3D-formed icons were mostly associated with graphical, image-based icons (see Figure 5).



Figure 5. Examples of three dimensional formed icons.

At the same time, 2D-formed icons were associated with text-based, image-based, and color-based icons (see Figure 6).

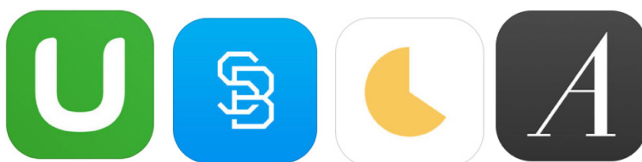


Figure 6. Examples of two dimensional-formed icons.

It was found that 3D-formed icons used more than three primary colors whereas 2D-formed icons used less colors.

Color. The process of analyzing the color design element was reviewed by examining the number of colors used in each icon. The idea was to measure the simplicity and complexity of each icon. Therefore, this analysis is discussed in detail through a quantitative visual analysis. Varieties were found across the sample icons in terms of the number of colors used in each icon. Across the sample icons, there were icons with two colors icons, icons with three colors, and icons with more than three colors (see Figures 7, 8, and 9).

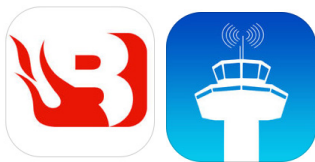


Figure 7. Examples of icons with two colors.

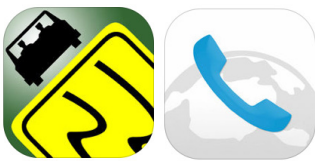


Figure 8. Examples of icons with three colors.



Figure 9. Examples of icons with more than three colors.

Texture. The texture element was used repeatedly when multiple texture elements were used in one single icon. Moreover, some types of texture were used frequently as the background element of the icon and others were used regularly as the foreground element of the icon. For instance, unified color and color gradation were used as background textures for most sample icons in this study. On the other hand, graphical images, images, texts, and abstracts were used as foreground elements for most sample icons (see Figures 10 and 11).



Figure 10. Examples of unified color textures.



Figure 11. Examples of color gradated textures.

Space. Although the size of the mobile application icon was very tiny, usage of space was noticeable--whether the space was medium or narrow. However, it appeared narrow-spaced icons were the majority among selected sample icons compared to medium-spaced icons. Furthermore, narrow-spaced icons were most often associated with graphical image-based and 3D-formed icons (see Figure 12).



Figure 12. Examples of narrow-spaced icons.

Likewise, medium-spaced icons were frequently associated with abstract, text-based, and 2D-formed icons (see Figure 13).

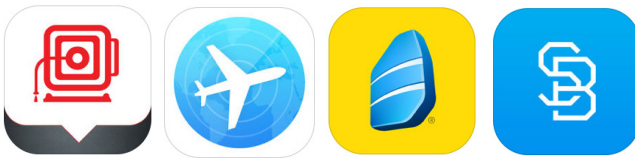


Figure 13. Examples of medium-spaced icons.

Principles of design. In general, visual analyses of the sample icons selected for this study indicated the principles of design were scarcely implemented in mobile application icons. For instance, among the sample icons, only a few icons used a *pattern* principle of design (see Figure 14). Also icons that used the pattern principle were abstract icons (see Figure 14).



Figure 14. Examples of the use of pattern in mobile application icons.

Visual analyses showed the *contrast* design principle was significantly used; however, it was used when utilizing color contrasting rather than other element contrasts. In other words, it was used in contrasting two contrary colors such as white versus black or dark colors versus shiny colors (see Figure 15).



Figure 15. Examples of the use of color contrast in mobile application icons.

The *balance* design principle was also repeatedly used in mobile application icons. The use of balance was to equalize horizontal and vertical elements and spaces in the icon (see Figure 16).



Figure 16. Examples of the use of balance in mobile application icons.

The three-design principles--pattern, contrast, and balance--were the commonly used principles across the sample icons; however, visual analyses did not indicate a significant use of the other design principles such as emphasis or harmony.

Phase II: Quantitative Visual Analysis

Research Question 2

The goal of this phase was to examine how each category differed from the other in applying the elements and principles of design in mobile application icons. In this phase, no deep statistical tests or hypotheses were utilized; however, this phase of analysis calculated the frequencies of how each unit was applied, determined the percentage of each element or principle as a single unit, and concluded the overall percentage of the whole app category.

Elements of design.

Shape. As mentioned earlier, Apple's standard shape is the rounded square; designers have no options to use another shape as the frame of the icon. However, there are a few attempts at implanting other shapes inside the rounded square. A quantitative analysis concluded that out of 120 sample icons, 16 icons used other shapes--10 circles, 3 rhombi, and 3 rectangles. In percentages, 13.33% of the examined icons used other shapes besides the rounded square: 62.5% were circles, 18.75% were rhombi, and 18.75% were rectangles (see Table 2).

In terms of category comparisons and based on visual analyses, there was no implantation of any shape across the Games icons. However, 30% of the Finance icons, 20% of Education icons, 15% of Travel icons, 10% of Sports icons, and 5% of News icons implemented the shape element in their icons (see Figure 17).

Table 2

Frequencies and Percentages of the Shape Element in Mobile Icons

	Rounded Square	Circle	Rhombus	Rectangle	Overall
Education	20 (100%)	2 (10%)	2 (10%)	0	4 (20%)
Finance	20 (100%)	5 (25%)	0	1 (5%)	6 (30%)
Games	20 (100%)	0	0	0	0
News	20 (100%)	1 (5%)	0	0	1 (5%)
Sport	20 (100%)	0	0	2 (10%)	2 (10%)
Travel	20 (100%)	2 (10%)	1 (5%)	0	3 (15%)
Overall	100%	7.5%	2.5%	2.5%	13

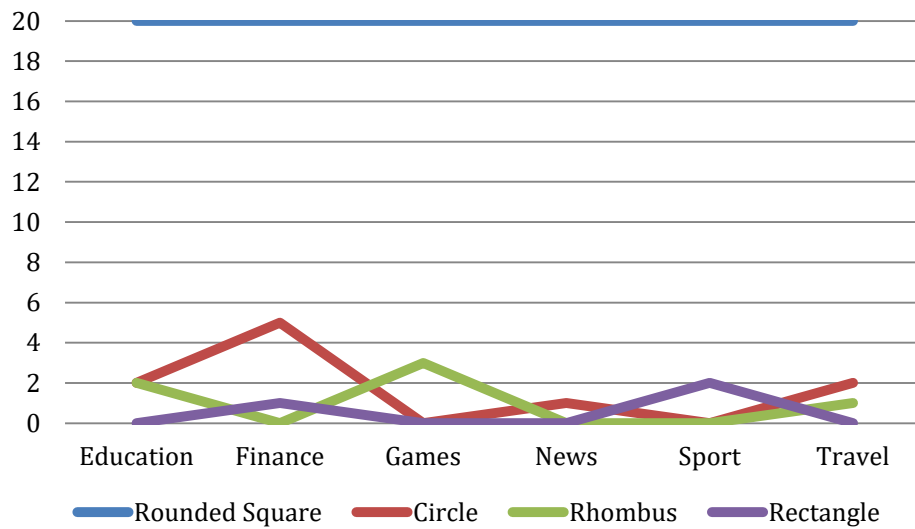


Figure 17. The use of different shapes in mobile app icons.

Form. Analyses of the form element of design concluded the majority of examined icons were 2D-formed. As an overall comparison, out of 120 sample icons, 83 icons (69.17%) were 2D-formed. On the other hand, 37 (30.83%) were 3D-formed icons (see Table 3).

As a comparison across app categories, Games apps used 100% 3D-formed icons; however, Travel used 85% 2D-formed icons, Education and Finance used 75% 2D-formed icons, and News and Sports used 90% 2D-formed icons (see Figure 18).

Table 3

Frequencies and Percentages of Three Dimensional and Two Dimensional-Formed Icons

	3d	2d
Education	5 (25%)	15 (75%)
Finance	5 (25%)	15 (75%)
Games	20 (100%)	0
News	2 (10%)	18 (90%)
Sport	2 (10%)	18 (90%)
Travel	3 (15%)	17 (85%)
Overall	30.83%	69.17

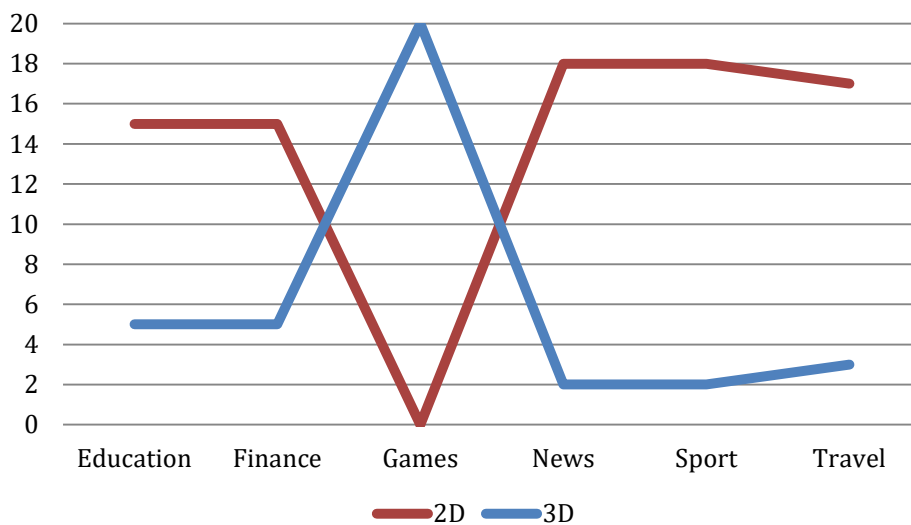


Figure 18. Use of two dimensional and three dimensional-formed icons across the apps categories.

Color. Usage of the color principle of design across the selected categories is summarized as follows. There was a significant pattern in some categories in terms of number and percentage of colors used in one single icon: Games category--three colors (100%), News—two colors (65%), Travel and Finance-- two colors (50%), and Sports-- three colors (50%; see Table 4 and Figure 19).

Table 4

Number of Colors in Single Mobile Icon

	2 Colors	3 Colors	More than 3 Colors
Education	8 (40%)	7 (35%)	5 (15%)
Finance	10 (50%)	6 (30%)	4 (20%)
Games	0	0	20 (100%)
News	13 (65%)	5 (25%)	2 (10%)
Sport	3 (15%)	10 (50%)	7 (35%)
Travel	10 (50%)	8 (40%)	2 (10%)
Overall	36.66%	30%	33.33

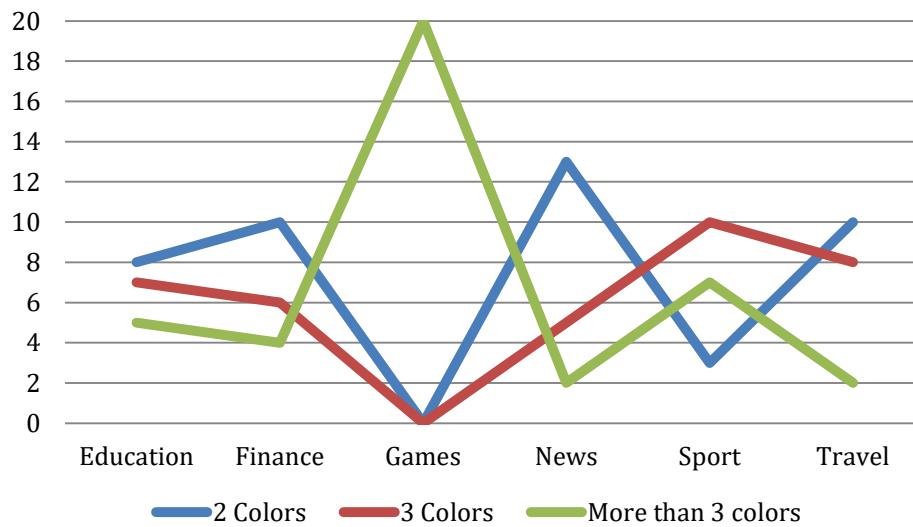


Figure 19. Use of color across app categories.

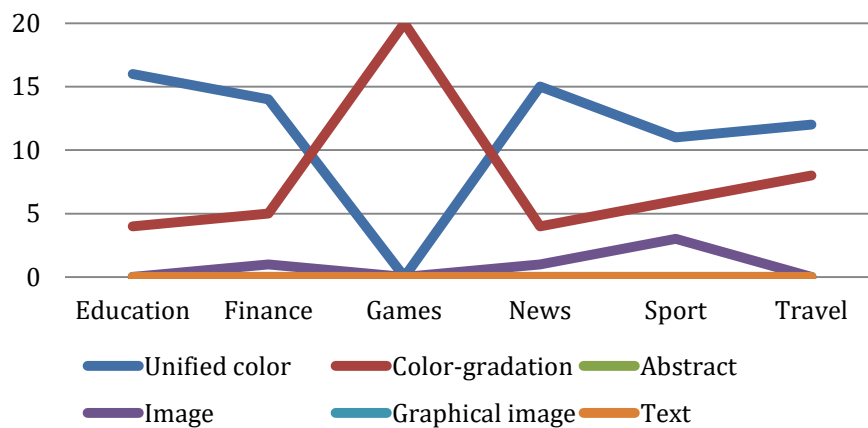
Texture (background). Most of the examined icons' backgrounds were textured by either a unified color or a color gradation. In particular, out of 120 icons, 68 (56.66%) icons had a unified color, 47 (39.16%) icons were color gradated, and 5 (3.33%) were image textured (see Table 5).

The Education category's icons were 80% unified in color and 20% color gradated; Finance icons were 70% unified in color, 25% were color gradated, and 5% were imaged; Games icons were 100% color gradated; News icons were 75% unified in color, 20% were color gradated, and 5% were imaged; Sports icons were 55% unified in color, 30% were color gradated, and 15% were imaged' and Travel icons were 60% unified in color and 40% color gradated (see Figure 20).

Table 5

Use of Texture in the Background of Icons

	Unified color	Color-gradation	Abstract	Image	Graphical image	Text
Education	16 (80%)	4 (20%)	0	0	0	0
Finance	14 (70%)	5 (25%)	0	1 (5%)	0	0
Games	0	20 (100%)	0	0	0	0
News	15 (75%)	4 (20%)	0	1 (5%)	0	0
Sport	11 (55%)	6 (30%)	0	3 (15%)	0	0
Travel	12 (60%)	8 (40%)	0	0	0	0
Overall	68 (56.66%)	47 (39.16%)	0	5 (3.33%)	0	0

*Figure 20.* Use of background texture across app categories.

Texture (foreground). In terms of an icon's foreground texture, visual analysis showed most of the examined icons had abstract, a graphical-image, and/or had a text-based foreground. Also, in some cases, there were icons that used more than one textural element. Out of the sample of 120 icons, 54 (75%) had graphical images in the foreground, 62 (51.66) had text in the foreground, and 42 (35%) had abstract elements in the foreground (see Table 6).

Table 6

Use of Texture in the Foreground of Icons

	Unified color	Color-gradation	Abstract	Image	Graphical image	Text
Education	0	0	10 (50%)	0	7 (35%)	6 (30%)
Finance	0	0	8 (40%)	0	8 (40%)	11 (55%)
Games	0	0	0	0	20 (100%)	10 (50%)
News	0	0	8 (40%)	0	4 (20%)	15 (75%)
Sport	0	0	8 (40%)	0	4 (20%)	16 (80%)
Travel	0	0	8 (40%)	0	11 (55%)	4 (20%)
Overall	0	0	42 (35%)	0	54 (75%)	62 (51.66)

Across the selected categories, graphical images were used in every category: Games(100%), Travel (55%), Finance (40%), Education (35%0, and News and Sports

(20%). Text in the foreground was used in every selected category: Sports (80%), News (75%), Finance (11%), Games (10%), Education (30%), and Travel (20%). Abstract elements in the foreground wa a common design method utilized in mobile application icons; 50% of Education apps, 40% of Finance, News, Sport, and Travel apps each used abstract elements in their icons (see Figure 21).

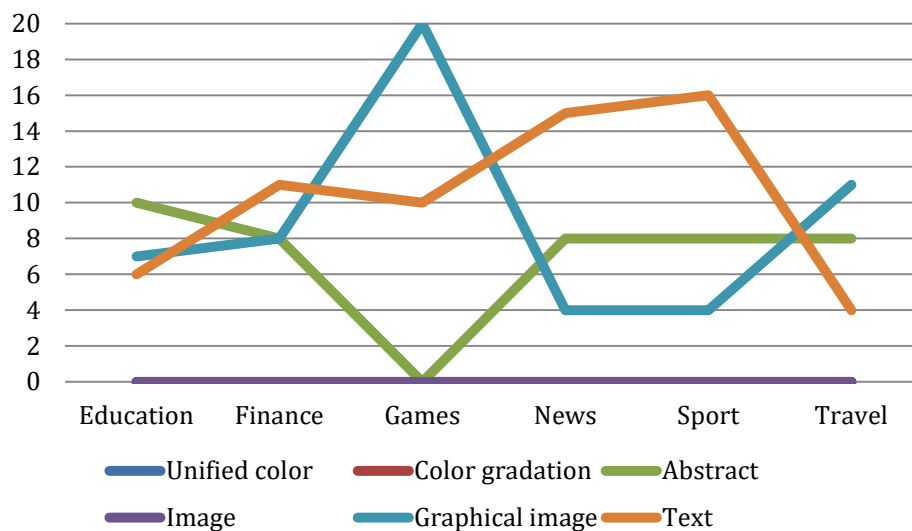


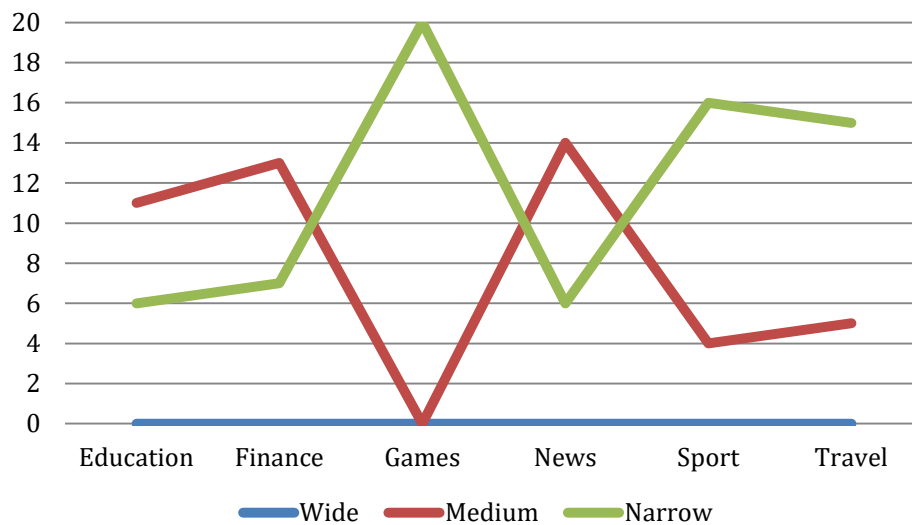
Figure 21. Use of foreground texture across app categories.

Space. A quantitative visual analysis concluded the space element of design was used in medium or narrow-spaced icons. Out of 120 sample icons, 70 (60%) icons were narrow-spaced and 50 (40%) were medium-spaced (see Table 7). Across the selected categories, 100% of Games, 80% of Sports, 75% of Travel, 35% of Finance, and 30% of Education and News each used narrow-spaced icons (see Figure 21).

Table 7

Use of Space in Mobile Icons

	Wide	Medium	Narrow
Education	0	14 (70%)	6 (30%)
Finance	0	13 (65%)	7 (35%)
Games	0	0	20 (100%)
News	0	14 (70%)	6 (30%)
Sport	0	4 (20%)	16 (80%)
Travel	0	5 (25%)	15 (75%)
Overall	0	(40%)	(60%)

*Figure 22.* Use of space across app categories.

Principles of design.

Pattern. The pattern principle of design was used by only 13 (10.83%) of the 120 sampled icons. Quantitative visual analyses concluded 25% of Travel icons, 20% of Education icons, and 10% of Finance and Sport icons each used the pattern principle of design but it was not used in Games and News (see Figure 23).

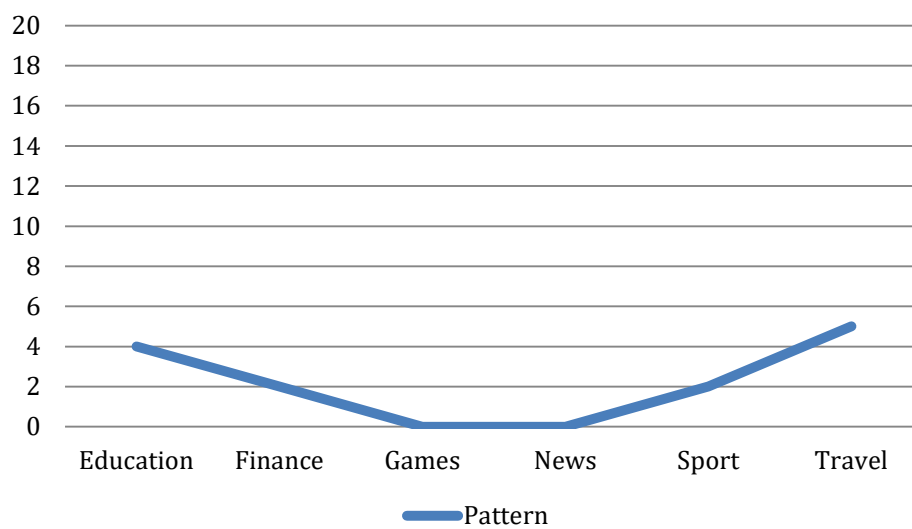


Figure 23. Use of pattern across app categories.

Contrast. Contrast, however, was used frequently in all app categories except the Games category. Out of 120 icons, 59 (49.16%) used the contrast principle of design. Across the selected categories, 80% each of News and Travel app icons, 70% of Sport app icons, 40% of Education app icons, and 25% of Finance app icons used the contrast principle of design (see Figure 24).

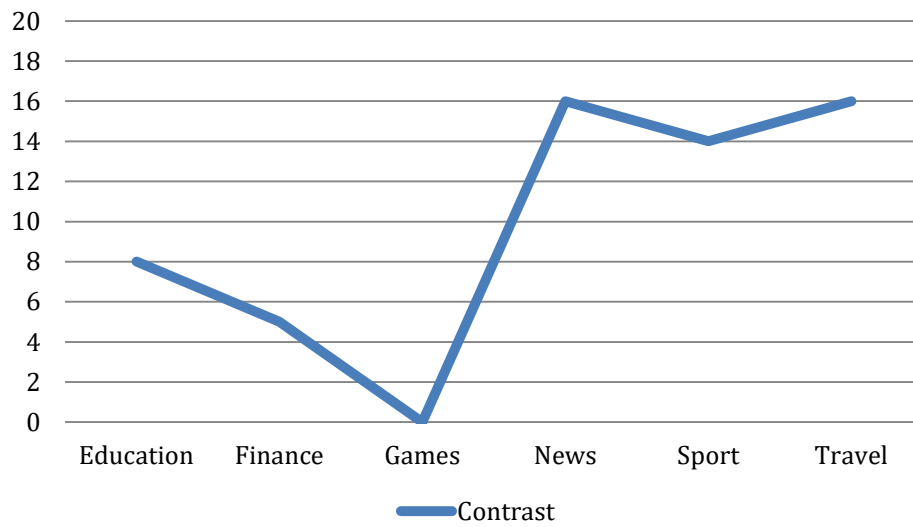


Figure 24. Use of contrast across app categories.

Emphasis. It was also concluded that the emphasis principle of design was scarcely used. Only four app icons (3.33%) out of 120 sample icons used it, i.e., emphasis was only used in the Finance app category (see Figure 25).

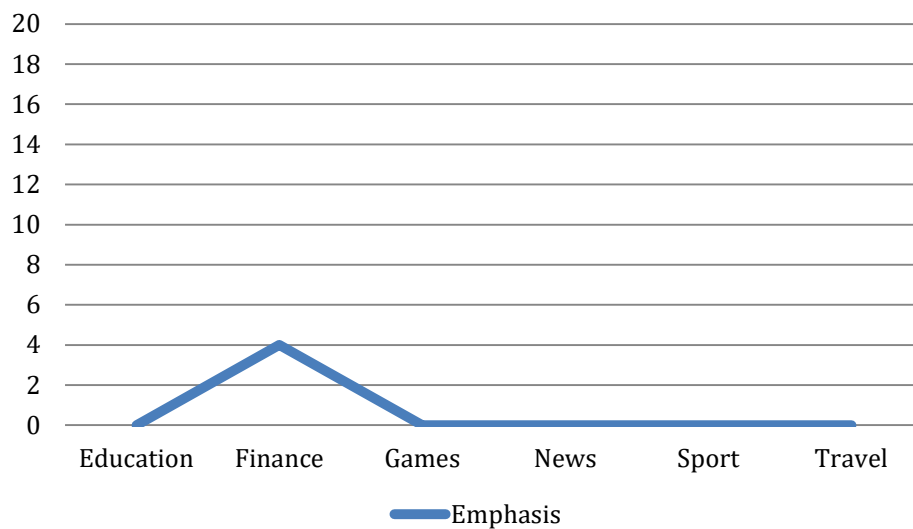


Figure 25. Use of emphasis across app categories.

Balance. The balance principle of design was significantly used in mobile application icons. From all selected categories, except the Games category, 30 (25%) of 120 sampled icons used balance. The Education and Travel categories were the highest in using balance (40% each), followed by Finance and News (25% each), and Sport (20%; see Figure 26).

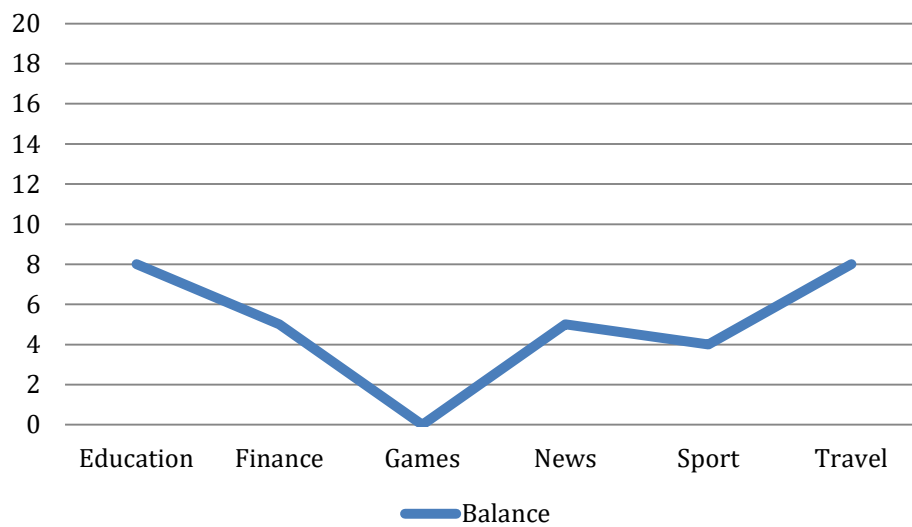


Figure 26. Use of balance across app categories.

Harmony. The harmony principle of design was not significantly employed in mobile application icons. Only two icons (1.66%) of 120 sample icons used harmony; the two harmony icons were in the Education category (see Figure 27).

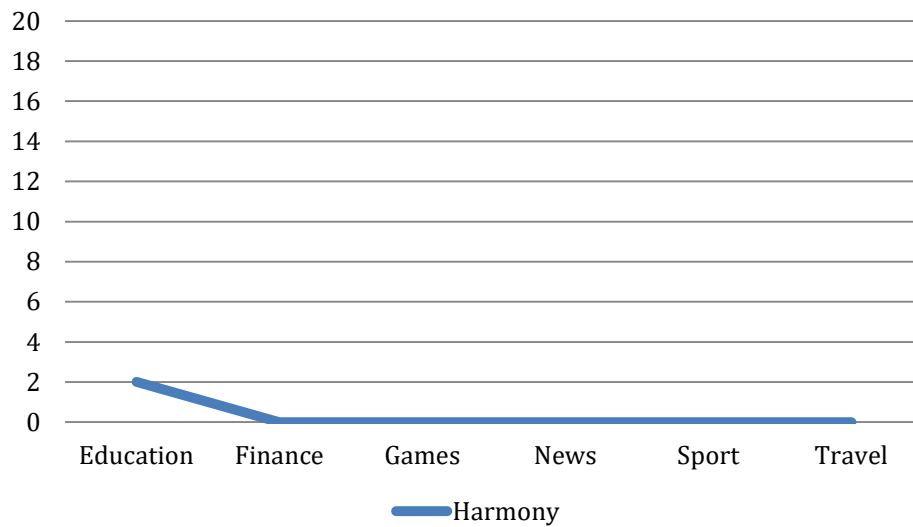


Figure 27. Use of harmony across app categories.

Table 8 provides a summary of the principles of design for each app category.

Figures 28 and 29 provide the use by each category of the principles of design.

Table 8

Summary of the Principles of Design for Each App Category

	Pattern	Contrast	Emphasis	Balance	Harmony	Overall
Education	4 (20%)	8 (40%)	0	8 (40%)	2 (10%)	22%
Finance	2 (10%)	5 (25%)	4 (20%)	5 (25%)	0	16%
Games	0	0	0	0	0	0
News	0	16 (80%)	0	5 (25%)	0	21%
Sport	2 (10%)	14 (70%)	0	4 (20%)	0	20%
Travel	5 (25%)	16 (80%)	0	8 (40%)	0	29%
Overall	13 (10.83%)	59 (49.16%)	4 (3.33%)	30 (25%)	2 (1.66%)	108 (19.66)

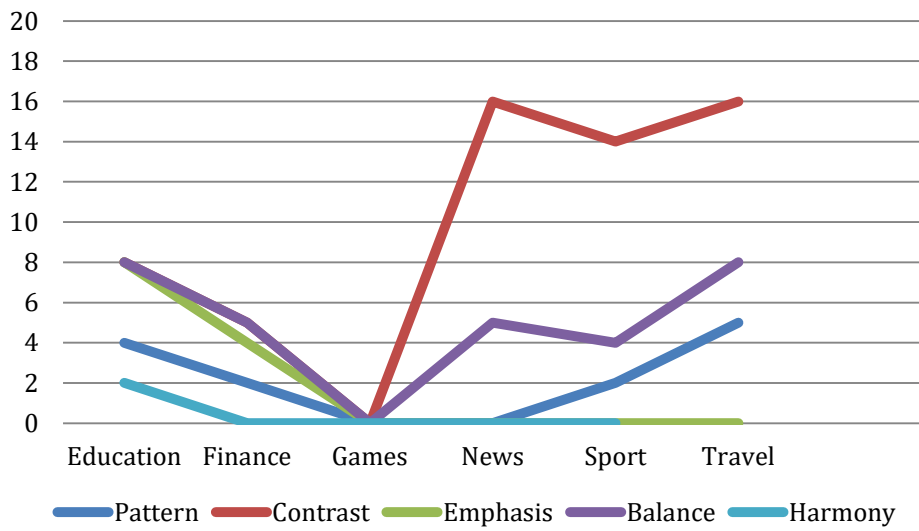


Figure 28. Use by each category of the principles of design.

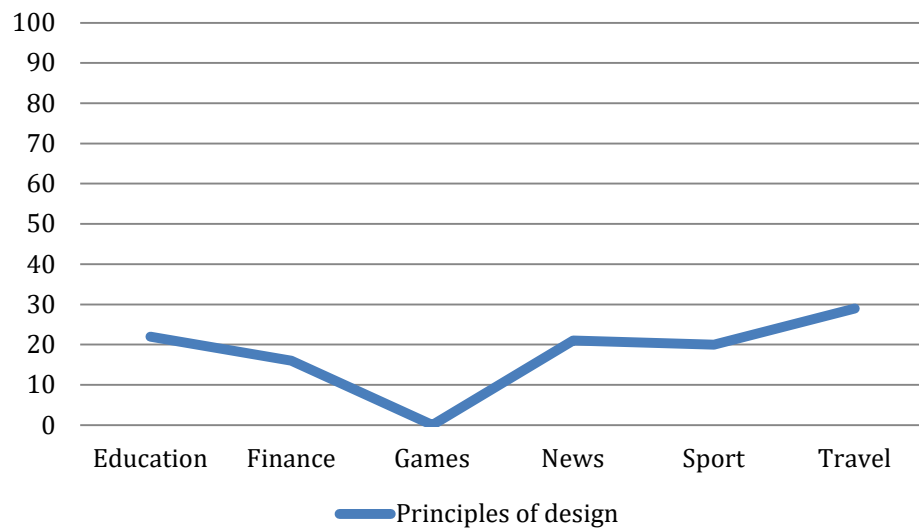


Figure 29. Overall use of principles of design.

Phase III: User Perceptions

Research Question 3

This phase linked the outcomes of the visual analyses, qualitatively and quantitatively, to mobile users' perceptions of mobile icon design. In this phase, participants were asked questions (see Appendix B) related to each icon's visual design and its impact on usability and communication. Moreover, an image solicitation was conducted to examine how much real mobile users could predict the outcomes of visual analyses.

Factors related to apps downloading and selection. In terms of what factors led participants to download an application and based on their interviews, participants mentioned various factors that led them to download mobile applications: social media, in-app advertisements, friends' recommendations, and random downloading. However, social media, according to them, played the most important role in recommending an application. For example, one of the participants pointed out that social media helped her know about new apps in two different ways--social media friends' recommendations and social media advertisements.

Likewise, mobile application users mentioned various factors that affected their usability and interaction when accessing the app store. These factors were summarized into three main factors: the app's rate, the app's review, and the app's icon. One of the participants indicated, "I look for the rate, how many stars on it, others' feedback I mean the review, and I do look at the icon as well... just having nice icons really may lead you to download those applications." Another added, "I look to the icons, because [icons] catch my eyes first, and then I click for more details." Another participant said, "I have

been using a dating app for a while then I saw an ad for another application that looks cool, but after I download it, it wasn't appealing at all, so the visual design of the icon is important but it is not everything."

Usability versus an app's visual design. In general, the visual design of the app was an important aspect in a mobile user's interaction and usability. One of the study's participants described the "hook": "[The visual design of the app] hooks me up to use the application." Another participant believed the visual design of the app, in general, must be fancy and modern. He pointed out, "When I download an app I expect to see cool design, if not, I feel that this is an old app." When he was asked to define what he meant by a "cool design," he said, "Cool design is to have nice graphics, nice color combinations." Finally and unexpectedly, none of the participants mentioned about an app's content organization or navigation.

When participants were asked questions about how much the visual design of the icon impacted their usability, communication, and interaction, their answers indicated the icon's visual design played an important role in their using experience. Based on their responses, the importance of the icon's visual design could be categorized into three main aspects: app selection, app impression, and app location. First, an icon's visual design influenced mobile users' decision when choosing an app from similar options in the app store: "I pick the one that looks cool". Second, it gave mobile users good or bad impressions about the app. Third, the visual design of the icon helped mobile users locate the targeted app easily and quickly from a full screen of different apps. An example given by one of the research subjects was Facebook and Snapchat because of their familiarity and the uniqueness of colors: "When you are familiar with the icon like

Facebook. Even when you have thinks were jumbled around, it is easy to fined Facebook much easier than other relevant apps because you are so familiar with that logo.”

Another added, “Because of the simple blue and the bright yellow, I can easily find Facebook and Snapchat in my phone.”

Image solicitation. The goal of image solicitation was to elicit mobile users in expressing their perceptions toward particular icons in order to examine how much their response could be related to what was found in the visual analysis phases. Participants were shown two groups of icons: (a) typical icons that followed each category’s design patterns as identified in Phase I and (b) icons atypical to their category in terms of design patterns. Therefore, during the solicitation, subjects mentioned only a few of the elements and principles of design. They mentioned the elements of design color, space, and shape and the contrast principle of design in the context of color: “I like the white silver with the black, a lot of contrast with that, defiantly something draws my eyes,” “creasy attractive, when I think about black and white,” “I like the circle,” “I like the colors,” and “The color is so bright.”

One of the image solicitation findings is participants were able to identify all the apps contents and categories based on their icons (see Figure 30). However, they were not able to identify any atypical apps’ content or categories properly when they were shown their icons (see Figure 31).

Application	Icon	Category	Statements
Homer – Learn to read program		Education	“It is very obvious that this app is for children” “So cute”
BillMinder – Bill reminder and organizer		Finance	“I see a Dollar symbol, budgeting app, it is about budgeting management” “I like the white silver with the black, a lot of contrast with that, defiantly something draws my eyes”
8 Ball Pool		Games	“Once you see the app, you know exactly what you are opening up”
The Boston Globe ePaper		News	“Looks like news app” “Honestly, creasy attractive, when I think about black and white and older text, I think about news paper”
GameChanger Baseball & Softball Scorekeeping		Sport	“Looks like a game center of a baseball” “looks very simple to me”
FlightTrack 5		Travel	“Travel” “travel app” “it is a travel” “Simple” “I like the white border around the logo, and I like the circle, it tells me I can travel around the world with them”

Figure 30. Typical icons.




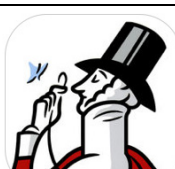

Application	Icon	Category	Statements
Mathway – Math Problem Solver		Education	<p>“It is confusing”</p> <p>“M & W? Management ways?”</p> <p>“What it the actual app is about?”</p>
Allowance & Chores Bot...		Finance	<p>“It doesn’t look as educational game, it is a normal game!”</p> <p>“Maybe this “game” is for a child, I would defiantly accept it for an adult but the eyes are slightly intimidating”</p> <p>“The color is so bright”</p>
Episode – Choose your story, feat		Games	<p>“A dating app!”</p> <p>“It is a dating application”</p> <p>“No, it is a game, I played that game”</p> <p>“It is a game!, if it’s a dating app would be very bad ‘cause I wouldn’t look for a dating app with a cartoon character.</p>
The New Yorker Magazine		News	<p>“Something for punish people?”</p> <p>“Abraham Lincoln?”</p> <p>“Looks like a monopoly guy”</p> <p>“I would guess this is a game”</p> <p>“This is interesting”</p> <p>“A gold dealer? Could be a financial app!”</p>
Golfshot: Golf GPS + Scorecard + Tee Times		Sport	<p>“Golf, defiantly yeah!”</p> <p>“That could be a game application or information application”</p> <p>“That could be a recording ... for music, I can see that”</p>
OBD Fusion – OBD2 vehicle scan tool		Travel	<p>“Engine?” “Engine light?” “A car?” “I think check engine light”</p> <p>“Could be like an automobile app to let me know what I need here and where I should go”</p> <p>“A mileage calculator? Maybe!”</p>

Figure 31. Atypical icons.

CHAPTER V

DISCUSSION

Communicating via icons is a popular method used in mobile devices. An icon's visual design is an important factor that impacts mobile usability, communication, and interaction (Luo & Zhou, 2015). Thus, this research was aimed at accentuating visual-related factors in mobile icon communication.

The purpose behind the research questions was to (a) highlight the use of principles and elements of design in mobile icons, (b) identify how the use of elements and principles of design varied across different app categories, and (c) evaluate how mobile user perceived an icon's visual design and its impact on mobile usability and communication.

The process of data collection went through multiple steps to pick the top-rated 120 apps from six different app categories including Education, Finance, Games, News, Sports, and Travel. Five mobile application users were then interviewed in a focus group interview setting. The interviews included two parts: (a) open-ended questions about users' perceptions toward a mobile icon's visual design and (b) image solicitation where participants were shown typical and atypical icons and asked to describe their reactions and perspectives of these icons.

As an exploratory, sequential, mixed methods design, the data were analyzed through three different phases. First, regardless of the app's category, sample icons were

visually analyzed and reviewed qualitatively to determine how each design element and principle had been employed in mobile icons (Phase I). Second, a quantitative visual analysis (Phase II) was conducted by calculating the frequencies and percentages of each element and principle of design highlighted in the qualitative phase. The third phase examined how mobile users perceived the outcomes of Phase I and by asking open-ended questions and image solicitations.

The results of the three phases concluded that the elements of design--shape, form, color, texture, and space--were widely implemented in a mobile icon's visual design. However, the principles of design--pattern, contrast, emphasis, balance, and harmony--were not implemented as widely as the elements of design. Also, the results concluded the most impactful elements of design were color and graphics. The quantitative visual analysis confirmed each app category had its own design trend. It was concluded that some mobile users were more attracted and confident with icons that followed a typical design. On the other hand, some mobile users were more attracted and confident with icons that did not follow a typical icon design. The results are discussed in more detail in the following sections.

Visual Design Versus Usability

Based on the results of the qualitative visual-analyses followed by the quantitative visual-analyses, significant variations were found among the selected app categories. Therefore, before designing an application's icon, it is recommended that designers review existing apps listed in a category relevant to the application under development. Moreover, results of users' perceptions confirmed that by looking at the app icon, they could figure out the icon's category and content. It would be against usability to design

atypical icons that do not follow its category's design pattern. For example, the Games app had 100% 3D-formed, colorful icons and the News app had 90% 2D-formed icons, so icon communication would be decreased with a 2D-formed Game icon or with a 3D-formed News icon.

The outcomes of both the visual analysis and the results of the users' perceptions emphasized that an icon's visual design is a very important aspect that influences usability, interaction, and communication. The impact of an icon's visual design could be summarized in three ways. First, an icon's visual design influences a user's decision in selecting an app when accessing the app store. One subjected commented, "When I have similar options to select from, I look for the rate, review, and the icons ... the cool icon design is a good sign for me to download the app." Therefore, because of the competition in app development, app developers must take into consideration the visual design of the app, which plays an important role in an app's attainment by mobile users. This could impact the popularity of the app or profits generated by initial app downloads. However, specific findings related to such statistics were outside the scope of this study.

The second important aspect of how the icon's visual design influenced mobile usability was its instant impression about the application; whether perceived as a good or bad impression, it evoked a reaction by the mobile user. For example, one of the mobile users commented, "Just having nice icons really may lead you to download those applications." Moreover, mobile users confirmed that the visual design of the icon was a real identity of the application itself. One participant commented,

It is not about the icon only, the app visual design [interface] is important too. ...I have been using a dating app for a while then I saw an ad for another application that looks cool, but after I download it, it wasn't appealing at all, so the visual design of the icon is important but it is not everything.

This comment also confirmed one aspect of the visual design, i.e., the visual appeal was a motivation to download the application.

Moreover, a third aspect that mobile users identified was how the visual design of the icon helped them easily and quickly recognize the icon on a mobile screen. For instance, the iPhone 6 displays 28 apps on a single screen; with so many to see at once, it takes time to distinguish them. The look of an icon could help with this identification. The design principle that helps mobile users recognize the app on a busy screen the most is *color*. When participants were asked about what visual aspects helped them recognize an app among a full screen of apps, they indicated that when the app had a unique color, it was easy to find because the color quickly caught their attention. When participants were asked about how the color of the icon influenced their impressions about the app, a mobile user pointed out, “[it does,] as long as a very fluent color scheme goes well together.” Also, during the image solicitation, one user stated, “I like the white silver with the black, a lot of contrast with that, defiantly something draws my eyes.”

Accordingly, the icon’s visual design is an important factor that impacts mobile usability and communication. This aspect plays an important role in terms of maximizing usability and communication, which lead the application to be popular and successful. Also, if the goal of human-computer interaction is to promote the interaction between user and device and to design a product that is friendly, enjoyable, and easy (Card et al., 1983), an icon’s visual design must be taken into consideration. In other words, if interactions are met, the app has a bigger chance to succeed; and when usability is maximized, the app has a more appealing usability. The icon is the exterior representation of the app, which means an attractive exterior design is a “good sign” or

the “hook” that leads one to download the app. Finally, the icon’s color is one of the most important elements in icon design. Because of the size of the mobile icon, color is the most used way to identify an app. Therefore, uniqueness of color selection is a big key to catch users’ eyes.

Icon Design Versus Elements and Principles of Design

In general, most elements of design were widely implemented in mobile application icons such as color, shape, form, and texture. The researcher also noted through the analysis that the use of design elements was not the same in mobile app icons as in other designing environments. As Robbins (2006) pointed out, the design elements and principles in a mobile device are not applied as the same as in a larger design fields. For example, because of Apple’s designing roles, the use of shape was limited to a shape inside the Apple’s standard shape--the rounded square.

Thus, it was concluded that the shape element of design was commonly used in mobile application icons. Because Apple standardized its app icon shapes, which is the rounded square, designers have had no choice in using different shapes as the base of an application icon. However, based on the visual analyses, different shapes can be used inside Apple’s standard shape (squares, circles, and rectangles). Additionally, participants in the interview claimed that utilizing different shapes made the icon catchier for the user. One participant pointed out that when an icon has a different shape, “it does fascinate my attention.” Moreover, the visual analyses revealed that when using different shapes, the background of the second shape had to be a unified color that delineated the second shape. Using a unified color as a background would help users quickly locate an app.

Additionally, both the visual analyses and the interview revealed that, in some contexts, using another shape helped users identify an app's content and category because it linked them to objects they already knew. For example, during the image solicitation, participants liked the idea of employing a circle as a representation of the earth in a travel app. One participant commented, "I like the circle, it tells me I can travel around the world with them." This outcome supported Heim's (2008) recommendation--to design icons so users can understand the relationship between the icon's visual design and its functionality, i.e., easier to be recognized and recalled. As Benson et al. (2004) indicated, well-designed icons are ones that reflect their contents and refer to the items they represent.

Both 2D and 3D forms were employed in mobile application icons. According to the visual analyses, it was recommended that 2D-formed icons be simple and graphics-free and 3D-formed icons be colorful, abstract, and graphic-based. Consequently, even with a tiny designing field, use of the form element is apparently broad where 3D-formed icons are popular.

Implementation of the color principle was reviewed by reporting the number of colors in each icon to determine its complexity. Based on the outcomes of the visual analyses, two or three colors icons were simpler, 2D-formed, and graphics-free. On the other hand, more than three colors icons were more complicated, 3D-formed, and graphic-based. Therefore, it was recommended to use less color with simple and non-graphical icons and to use more colors with complicated and graphical icons. For instance, applications icons more suitable to a simple design are News applications; conversely, application icons more suitable to a complex design would be in the Games

category. In other words, users perceived a News icon to be simple and text-based and a Game icon to be complicated, colorful, and graphical to meet users' perceptions of that particular icon. Huang (2009) emphasized that when considering people who are going to use the product, the product needs to be useful and usable.

Moreover, during the interviews, the participants mentioned the color element multiple times. They perceived color as the uniqueness of the color tone wherein no other icons used that color. For instance, they mentioned the color of Facebook--the matte blue and Snapchat--the bright yellow. According to them, the uniqueness of color helps mobile users locate the application between the other applications displayed on one single screen. For example, one of the subjects described how the familiarity of the icon's color helped him recognize the app. He stated, "When you are familiar with the icon like Facebook, even when you have thinks were jumbled around, it is easy to find Facebook much easier than other relevant apps because you are so familiar with that logo." Moreover, when participants were asked to define what they meant by "cool" colors in a mobile icon, they believed it was to combine different groups of colors in a courteous way. As illustration, several comments were made during the interviews: "creasy attractive, when I think about black and white"; "I like the white silver with the black," and "I like the white border" (Participant #3), which meant the color principle was a big factor that influenced mobile usability and communication.

Texture is an element commonly employed in mobile icons. Based on the visual analyses, use of the texture design element in an icon can be divided into two main types: background and foreground. Thus, as a background, it was recommended to use a unified color or a color gradation to give the foreground element a superior look.

However, when used as a foreground of the icon, a graphical image, image, or abstract texture was recommended. During the interview, one subject mentioned the white-colored background that highlighted the front element needed to be clearer.

In general, the size of mobile technology's screen is very small, which makes designing for a mobile technology more challenging (Gatsou et al., 2009). Because of the tiny screen size, mobile icons are very small, demanding more spacing to be recognized and seen on a mobile screen. Therefore, during the visual analyses, significant variations in the use of the *space* element were not found. Across the sample icons, only a few icons used a wide-space; most were narrow icons. Moreover, participants did not mention the space element as an important factor that influenced their usability and communication when using mobile applications. Accordingly, as long as the icon was visible and space-balanced, the space principle was not a major factor that influenced mobile usability and interaction.

Compared to elements of design, it was disappointing that no substantial embodiment of principles of design was found across the sample icons. The only implementation of principles design found was in pattern, contrast, and balance. The use of pattern was regularly used in other bases of design, e.g., the repetition of an object of an element. However, due to the smallness of the designing field, contrast was used in mobile applications only in color contrasting, i.e., contrasts between black and white or between dark and bright colors. Similarly, the balance principle was only used to equalize the balance between the foreground and surrounding spaces inside the icon.

Across the sample icons, no implementation of emphasis and harmony principles of design was found. A reason for this could be interpreted in two different ways. First

interpretation would be the size of the mobile icon compared to other art designing fields. Second, the principles of emphasis and harmony are advanced principles minimally used in art in general.

Implications

The qualitative visual analyses, quantitative visual analyses, participant interviews, and image solicitations revealed specific designing characteristics for mobile icons in general. Suggested guidelines for designing mobile icons were dependent on their categories.

According to the visual analyses, the recommended design pattern for the Education app category was as follows: (a) 2D-formed, (b) two or three colors, (c) a background textured with a unified color, (d) an abstracted element as a foreground element, and (e) medium-spaced.

Similarly, the recommended design pattern for the Finance app category was as follows: (a) 2D-formed; (b) two colors; (c) textured with a unified color as the background; (d) text-based, abstract-based, or a graphical image-based foreground; and (e) medium-spaced.

However, the Games app category had its own design trend. When designing a game icon, it was recommended that it (a) be 3D-formed, (b) have more than three colors, (c) be textured with a color gradated background, (d) have a foreground with a graphical image and text, (e) be narrow-spaced, and (f) be cartoon-based.

When designing a News category icon, the visual analyses recommended the icon be designed as follows: (a) 2D-formed, (b) two colors, (c) a background with a unified

color, (d) a foreground with a classic text, (e) medium-spaced, and (f) have a color contrast.

Moreover, the visual analyses suggested the Sports icon should be designed as follows: (a) 3D-formed, (b) three colors, (c) a background with a unified color, (d) a graphic or text-based foreground, and (e) narrow-spaced.

Lastly, according to the analyzed icons, the Travel icon should be designed as follows: (a) 2d-formed, (b) two or three colors, (c) background with a unified color, (d) foreground with a graphical image or an abstract element, and (e) narrow-spaced.

The outcomes of this research support the fact that graphics are important components in an icon's visual design. One participant commented, "We are in an age that graphics matter a lot, ...people now are looking for that clean graphics to getting closer and closer to realism!" Another participant added, "Graphics are very important." According to the visual analyses, graphics used must have a visual representation of the app's content. As Barnard (2009) emphasized, well-designed icons are ones that catch users' attention and inspire their humor and enjoyment. Hooper and Berkman (2011) described usable icons as ones that are easily recalled.

Finally, participants suggested the following general design guidelines. First, the icon should contain a symbol or an element that identifies the content and category of the application. For example, they liked the dollar symbol used in a financial app and they disliked the engine-light symbol used in a travel app. As Hooper and Berkman (2011) pointed out, well-designed icons serve as an easily understandable, easily recalled representation of an action or target destination such as a website or application.

Typically, icon designs have positively influenced mobile usability and communication. However, atypical icons have negatively influenced mobile usability and interactions. For instance, when participants were shown typical icons, they used appealing phrases such as “so cute” and “I like” as well as statements like “defiantly” and “exactly.” On the other hand, when they were asked about atypical icons, they used unappealing phrases such as “It is confusing,” “Something for...,” “I would guess,” “Could be,” “I think,” and “Maybe!”

Recommendations for Future Research

According to the reviewed literature, there is a gap in studying the icon as an important component in mobile communication. In general, because of its quick growth as well as its variety of users, the field of mobile communication and usability has issues and gaps that need to be addressed by researchers.

Since this research was limited to visual-related factors in mobile communication, further research is recommended to address other senses involved in mobile communication, e.g., hearing and touching. Additionally, this research was limited to six app categories. Future research is needed to include all app categories in a deeper quantitative comparison design to find significant differences among these categories. Outcomes of this research could be extended to a study that focuses on the impact of one important element such as color or graphics. Also, this research could be replicated using different icon samples or different types of mobile users. Finally, there is a need for research that predicts the future of designing mobile app icons by reviewing current design trends.

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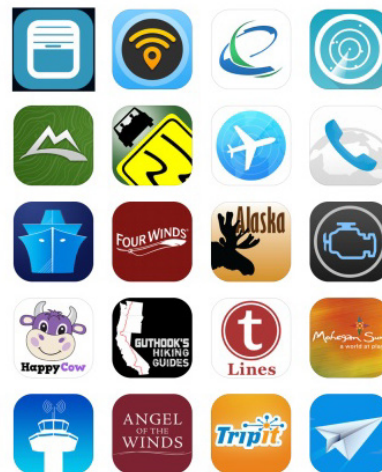
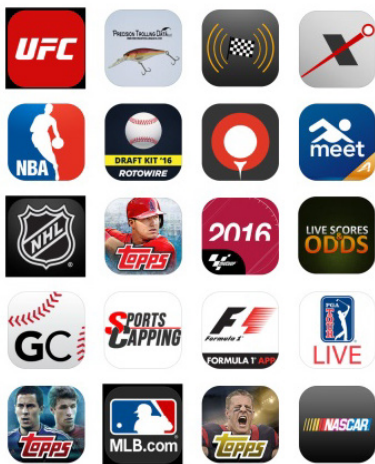
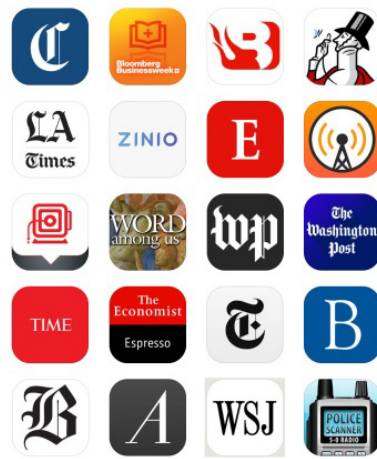
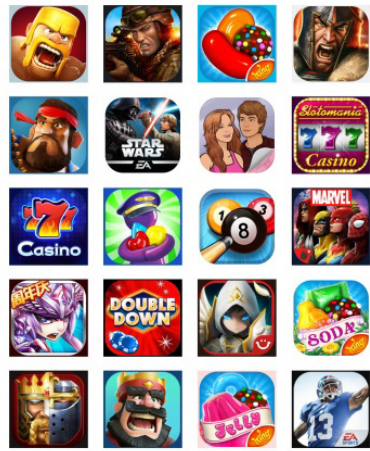
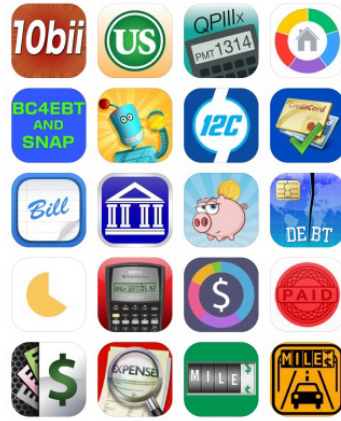
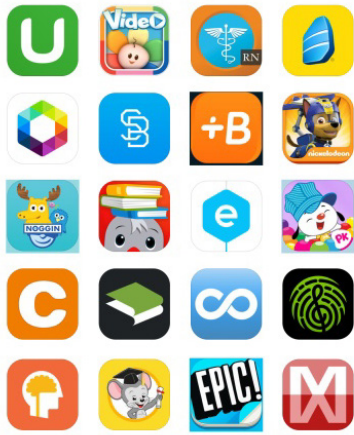
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APPENDIX A

TOP RANKED MOBILE APPLICATIONS



APPENDIX B
INTERVIEW QUESTIONS

INTERVIEW QUESTIONS

1. Icebreaking questions:

Name, age, type of phone.

2. Intro questions:

Do you use mobile applications,

- for how long?
- how often?
- your favourite apps?

3. Questions related to usability and interaction

- How easy to navigate in mobile app?
- do you enjoy using it?
- What makes you comfortable and non-comfortable when using the mobile apps?

4. Questions related to reasons of app selections and apps downloading factors:

- What factors leads you to download a mobile application?
- How did you know about the app? “e.g. adds, friends recommendations, social media, user review, app’s rate ...”
- What visual factors that most pay your attention to the app, “e.g. its icon, background, graphics, typography...”

5. Questions related to the app’s icon design:

- To which level do you agree that the apps icons are important in mobile design? and why?

- Does the visual design of the icon impact your impressions about the application?
- What visual aspects that mostly grab your attention to download the app's icon?
- Does the app's icon help you to locate the app in a fully screen of apps quickly?
- When accessing the app store, do you prefer the iconic or the textual communications?
- Can you figure out the application content or category by its icon?
- Does the color of the icon influence your impressions about the app?
- Does the graphics of the icon influence your impressions about the app?
- Can you name some apps that you like its icons and why?
- Can you name some apps that you dislike its icons and why?

I'm going to show you some mobile icons: can you describe its content and its app category by looking to the icon?

APPENDIX C

INSTITUTIONAL REVIEW BOARD APPROVAL



Institutional Review Board

DATE: March 21, 2016

TO: Mohammed Alsuwailem

FROM: University of Northern Colorado (UNCO) IRB

PROJECT TITLE: [877356-2] Visual-related Factors in Mobile Iconic Communication

SUBMISSION TYPE: Amendment/Modification

ACTION: APPROVAL/VERIFICATION OF EXEMPT STATUS

DECISION DATE: March 21, 2016

Thank you for your submission of Amendment/Modification materials for this project. The University of Northern Colorado (UNCO) IRB approves this project and verifies its status as EXEMPT according to federal IRB regulations.

Mohammed -

Thank you for swiftly submitting modifications and explanations of protocols as requested. Please be sure to use these revised materials in your participant recruitment and data collection.

Also, please carefully review your materials (e.g., recruitment email and consent form) and correct spelling and grammar errors before use in your protocols.

Best wishes with your research.

Sincerely,

Dr. Megan Stellino, UNC IRB Co-Chair

We will retain a copy of this correspondence within our records for a duration of 4 years.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Northern Colorado (UNCO) IRB's records.

APPENDIX D

CONSENT FORM TO PARTICIPATE IN HUMAN RESEARCH



CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Visual-related Factors in Mobile Iconic Communication
Researcher: Mohammed Alsuwailem., School of Education and Behavioral Sciences.,
Department of Educational Technology.
Phone: (720) 401-2108
E-mail: alsu2373@bears.unco.edu

Purpose and Description: The rapid growth of mobile applications informed this research and prompted questions about the design of an application's icon for mobile devices. In small-sized mobile technologies, it is common that mobile applications are displayed in the form of small-touch icons. Yet, what are the patterns for designing a mobile application's icon, what are the visual-related factors entailed in the process of designing the icon, and what are the standards and the guidelines when designing a mobile application's icon, these questions need to be addressed and shared to application developers, instructional designers, and marketers.

The purpose of this study is to highlight the visual characteristics and design patterns of mobile applications' icons. The results of the study are expected to be beneficial for both mobile-applications developers as well as mobile users. It has been beneficial for application developers to follow current patterns when designing mobile icons. Also, it is beneficial for mobile users to recognize the natural of the application by knowing its design patterns and what factors that maximize their communication within the device. Because designing mobile applications has become available for everyone, there is a need for research of current design patterns to provide some designing tips and roles that will increase users' interaction, usability, and communication.

Your task, as a participant is to share your thoughts and perceptions as a mobile application user. You'll be asked questions related to your experience using mobile applications. The interview will include questions that address facts that affect your usability, interaction, and communication within the mobile device through the use of mobile applications. Moreover, the interview includes questions follow a photo-elicitation format using images of mobile app icons, which help the researcher to understand how the visual design of the application's icon affect your usability, interaction, and communication.

Potential risks in this project are minimal. The risks are not foreseeable in this study beyond those incurred in having a casual conversation with peers, and there are no

foreseen benefits to the subject. The type of data that used is minimal benefit. The cost for this study is inexpensive. There is no cost or compensation that will be paid out to the participants.

Data collected and analyzed for this study will be saved in a locked cabinet in my advisor's office wherein no one has access to that data except me, as a researcher, and my advisor. At the end of the interview, I would be happy to share your data with you at your request. I will take every precaution in order to protect the confidentiality of your participation.

The estimated duration of this interview is about 45 minutes long. Please note that participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. You should know that the data collected and analyzed for this research are going to be published under the UNC dissertation and theses publications.

Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado Greeley, CO 80639; (970) 351-1910.

Subject's Signature

Date

Researcher's Signature

Date

APPENDIX E

EXAMPLE OF PHASE I ANALYSIS WORK SHEET I





Analysis Work Sheet I

Apps' icon		Elements of design					Overall	
		Shape	Form	Color	Texture			Space
		Circle Triangle Square Rectangl e Rhombus Oval	2d 3d	# of colors	Actual Abstract Textual Tonal Color- gradation Color		Wide Medium Narrow	
					Background	Foreground		
	1							
	2							
	3							
	4							
	5							
	6							

APPENDIX F

EXAMPLE OF PHASE I ANALYSIS WORK SHEET II

Analysis Work Sheet II

Apps' icon		Principles of design					
		Pattern	Contrast	Emphasis	Balance	Harmony	Overall
	1						
	2						
	3						
	4						
	5						
	6						