The More You Know, the More You See:

M-learning of visual literacy skills.

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A thesis submitted to Auckland University of Technology in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD).

2018

School of Communication Studies

Abstract

Changing technology has created new demands on how people communicate, with the average person now needing to communicate more visually to fully participate in the contemporary world. This has prompted renewed interest in the learning of visual literacy skills. Based on the presupposition that visual literacy skills are not usually learned unaided “by osmosis” but require targeted learning support, this research explores how everyday encounters with visuals can be leveraged as contingent learning opportunities. The study proposes that a learner’s environment can become a visual learning space if appropriate learning support is provided. This learning support may be delivered via the “anytime and anywhere” capabilities of mobile learning (m-learning), which facilitates peer learning in informal settings. The study found that personalised learning, situated learning, and collaborative learning significantly assist visual literacy learning.

Informed by a review of existing learning models, the study propositions a rhizomatic m-learning model of visual skills. The learning model describes how everyday visuals may be leveraged as visual literacy learning opportunities. By devising a tailor-made practice-based research approach, the visual learning model was implemented and tested as an m-learning app. Usability testing and interviews were used to evaluate the app as a learning application, as well as the underlying learning model. The outcomes of the study demonstrate that visual literacy can be achieved by novice learners from contingent learning encounters in informal learning environments through collaboration and by providing context-aware learning support. This finding is encouraging for teaching visual literacy, as it shifts the onus of visual literacy learning away from academic programmes and, in this way, opens an alternative pathway for the learning of visual skills.

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Attestation of authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Matthew Guinibert

Acknowledgements

To my wife, Christine – thanks for your patience, support, and cups of tea throughout all my studies. My days are infinitely brighter knowing that you are part of them.

To my family, I still suffered premature hair loss, but I am chalking that up to genetics and not stress due to lack of support. Thank you for your continuous encouragement and help over the years.

Thanks God – you're the man/supreme-being.

To my supervisors, Petra Theunissen and Thom Cochrane – if only a fraction of your knowledge rubbed off I will be leagues ahead of where I was four years ago. Thanks for granting me the freedom to explore a hunch and for all your support.

Thanks to Gudrun Frommherz for her feedback and structural advice.

Thanks to my colleagues Abhi Kala, Justin Matthews, and Ross Brannigan. Your insights and input throughout the process were invaluable.

Thanks to AUT and the School of Communication Studies for their ongoing support throughout this research. Special thanks to AUT's Vice Chancellor for an academic study leave award in 2016, which allowed me to complete this research.

I acknowledge the proofreading assistance of Suzanne Hardy, who read the final draft of this thesis.

Thanks to all the participants of this study. Not only did your input make this research possible, your passion for the subject also provided the motivation to finish.

Lastly, a big thanks to all my students throughout the years. Your feedback, insights, and enthusiasm for learning are what conceived this research's initial direction. Without all of you, I would still be twiddling my thumbs searching for direction—both in research and life.

Ethics approval

This research obtained ethical approval 16/156 from the Auckland University of Technology Ethics Committee (AUTEC) on the 6th of May 2016.

Chapter 1: Introduction

1.1 Overview

Changing technologies have created new demands on how people communicate and what it means to be literate (Hanifan, 2008). This demand has prompted renewed interest in the learning of visual literacy. This study aims to address this need by exploring how the visuals one encounters every day can be leveraged as opportunities for learning visual literacy. The aim operates on the presupposition that a person is surrounded by visuals in their everyday environment which they could potentially analyse to deepen their knowledge. However, learning from visuals in one's environment is often beyond the capabilities of novice learners, due to a lack of learning support in this informal learning setting. The research proposes that applying the anywhere and anytime affordances of m-learning to learning visual literacy may provide learners persistent access to peer learning support so that they may acquire visual literacy from their environment.

The exploration of this study's aim utilises a tailor-made practice-based research approach that draws on heuristic inquiry and user-centred design. The exploration includes planning of two key outcomes. Firstly, a learning model that describes how everyday visuals may be leveraged as visual literacy learning opportunities. Secondly, a prototype of an m-learning app that is a practical implementation of the learning model. Both outcomes are tested and confirmed or refined to form the final thesis of this study.

In this introduction chapter, the need for visual literacy is outlined and posited in this study. Next, the study problematises visual literacy learning in informal learning scenarios, describing how a lack of peer learning support may prevent novice learners from acquiring visual literacy. A potential solution to the problem is then identified in the affordances of mobile learning (m-learning). This study's research questions are then posed, concluding in the final section by clarifying the significance of the study and structure of the thesis.

1.2 A Case for Visual Literacy

Traditional literacy has focused on reading and writing text. However, in recent years the definition of literacy has evolved to include further means of communication. The average person today needs to decode and process information from many different formats and media to fully participate in the contemporary world (Tertiary Education Commission, 2008; Hanifan, 2008). Hanifan (2008) claimed that in addition to reading and writing printed text, literacy now includes the use of auditory, visual, and digital content. The New Zealand Tertiary

Education Commission (TEC) takes a similar stance and stated that competency in these media are necessary to be a functional and productive member of society and the workforce (Tertiary Education Commission, 2015). It is no surprise then that scholars such as Hanifan (2008) and Cope and Kalantzis (2009), as well as New Zealand government bodies such as the TEC, have called educators to consider more than the education of just reading and writing printed text in this new multi- media saturated era. This pressure to encode and decode various media has seen "literacy" redefined and expanded into "multiple literacies" (Cope & Kalantzis, 2009). Proponents of multiple literacies, such as Cope and Kalantzis (2009), believed there is no one singular concept of learned mastery, instead dividing literacy into smaller fields or sub-domains based on social and cultural practices. Visual literacy is one such sub-domain of literacy.

Following the invention of photography some 170 years ago, images have played an increasingly important role in contemporary society (Barnes, 2011). With recent technological advances in digital image capture, creation, and sharing, there has been an increase in visuals being used for more than just aesthetic or artistic purposes (Frascara, 2004). Visuals have become common place as a means for imparting and receiving ideas, resulting in the average person seeing more images than text in their lifetime (Lester, 2011). This impact can be seen in the use of mobile communication such as Facebook Messenger or iOS's default messenger application, which include the ability to communicate with gifs, memes, stickers, customisable emoticons, drawings, and photos as salient features. Features such as these have proved popular with consumers to the extent that Facebook's user base shared on average two billion images daily in 2015 (Bandaru & Patiejunas, 2015). While there are valid arguments for text to be the dominant means of preserving information, there is an increasing recognition that "print no longer dominates the transfer of information" (Marcum, 2002, p. 15). This has seen an increased interest in both how people communicate with images, and how people learn the broader skills of visual literacy (Marcum, 2002).

Marcum's (2002) stance can be corroborated by examining statistics from the World Internet Project, which shows that New Zealanders rate the importance of television and the internet as information sources above that of newspapers (Crothers, Smith, Urale, & Bell, 2016). Market research on the consumption of different media from the year 2013 also demonstrated the importance of visuals, with the average American spending 279 minutes daily watching television, 169 minutes online, 142 minutes on tablets, 122 minutes on smartphones, 33 minutes reading magazines, and 30 minutes reading newspapers (Statista, 2014a). These figures show that we daily consume enormous amounts of media that contain visuals.

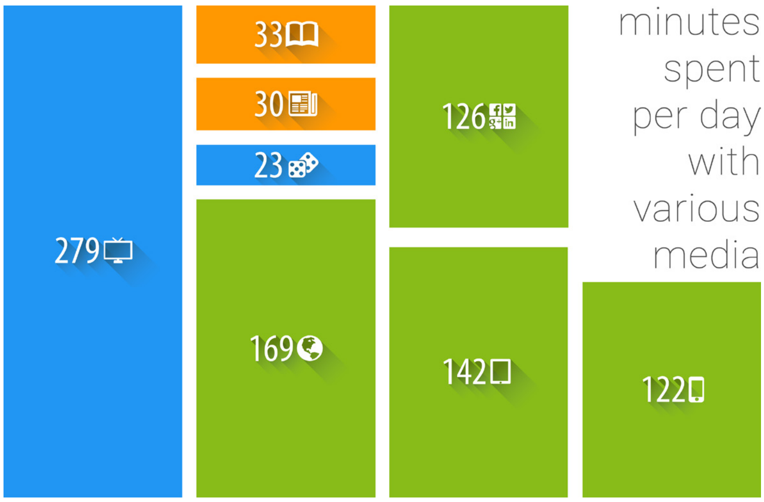


Figure 1-1: A visualisation of minutes spent per day, per person, with various media as reported in Crothers, Smith, Urale, and Bell (2016).

The recent increase in the consumption of visuals is a result of new technologies such as the internet, social media, personal computing, smart phones, digital photography, digital content delivery, and video games, all of which are pressing us to communicate through visuals (Bleed, 2005; Spalter & Van Dam, 2008). Given this, Spalter and Van Dam (2008) believed that these digital devices and platforms are amplifying the necessity for visual literacy skills. Further, Aviram and Eshet-Alkalai (2004; 2006) believed that visual literacy is a core constituent to digital literacy, as visual literacy skills help users to read and understand instructions and messages that are presented in pictorial and graphical forms, as is the case with most digital interfaces. Spalter and Van Dam (2008) argued that visual literacy is now essential for many daily life and workplace tasks, such as "looking critically at newspaper images or TV evening news, to using a digital camera, making a Web site, creating presentations, and modeling and visualizing data in virtually all of the sciences" (p. 93). Spalter and Van Dam's view is not new. Dake (1993) made a similar observation over 20 years ago, well before the arrival of social media as we know them today. He also stated that while the increasing need for visual literacy skills is a result of contemporary technology, *the skills themselves are not technology specific*.

The call for visual literacy can be traced back to Arnheim (1969), who not only noted their importance, but called for educators to start teaching them. Dondis (1973) agreed and stated that despite cultural changes leading to the increased consumption of imagery, visual literacy had not gained as much traction in education as proponents would have hoped for, especially when compared to its text counterpart. This critique was echoed some forty years on by Bleed (2005, p. 3), who agreed by stating, "Visual literacy is required of us as much as textual literacy. Most academic programs, however, are centered on reading and writing words". Lester (2011) contended that "bombarded daily with a steady, unrelenting stream of visual stimulation from all manner of media, we need to understand pictures" (p. x).

A potential reason for a lack of visual literacy in contemporary learners stems from the prevailing ‘digital native’ narrative. This narrative assumes that contemporary learners have acquired digital literacy skills and associated visual literacy skills as a result of constant exposure to contemporary technology (Bennett, Maton, & Kervin, 2008). In relation to this narrative, visual literacy would not therefore need to be taught; learners would just know from their environment and learn by 'osmosis'. This does not appear to be the case, however. Spalter and Van Dam (2008, p. 91) stated that although young people may seem proficient users of visual technologies, “most are unaware of the principles underlying the tools they so readily adopt and cannot make important connections between types of visual technology and its uses”. A study by Brumberger (2011) corroborated this claim. She concluded that Millennials’ repeated interaction with visual material through technology has not resulted in enhancing their visual literacy. Her study demonstrated that visual literacy learning does not just occur from interacting with visuals, but needs some level of learning intervention.

Another argument for learning visual literacy is that understanding images helps identify and build resistance against the manipulation and visual persuasion strategies of TV commercials, political campaigns, and advertisements (Avgerinou & Ericson, 1997; Barnes, 2011; Marcum, 2002). The average person today encounters visual messages that attempt to persuade, change, and influence thought, often without the beholder’s awareness. These messages cannot be avoided as they have become pervasive in both public and private spaces (Avgerinou & Ericson, 1997). Without visual literacy, how is the average person to distinguish whether a visual message is valuable, factual, or manipulative? Visual literacy provides a means to critically think about images, which allows a person to arrive at their own conclusion, rather than merely being a passive sponge, uncritically absorbing visual messages. Therefore, visually literacy provides some protection against unavoidable visual manipulation (Marcum, 2002).

Developmental psychology purports that acquiring visual literacy skills may also improve cognitive abilities. It is argued that as vision is the most dominant of all our senses, a high proportion of all sensory learning is therefore visual (Avgerinou & Ericson, 1997; Olson, 2007; Piaget, 1971; Wade & Swanston, 2001). This claim appeared to be based on neurophysiological (the physiology of the nervous system) studies which stated that roughly 60% of the brain is involved with vision and a third of that is solely dedicated to processing vision, which is much higher than any other sense (Keller, Bonhoeffer, & Hübener, 2012). The claim that visual literacy can improve one’s cognitive abilities is supported by examining cognitive development theory. Bruner (1957) established that there are three ways information can be stored in memory: enactive, iconic, and symbolic. The *enactive* stage of learning occurs from ages zero to one, and involves encoding and storing action-based information, such as muscle memory. The *iconic* stage states that learners can store and encode visual information in their memory, playing a dominant role in a child's development from one to six years old. This is followed by the ability to encode and remember *symbolic* information such as language. Children therefore learn to encode and remember visuals before they learn language, meaning the memories (or schemata) that language is built upon are visual. Bruner (1957) believed that moving through a process of enactive, iconic, and then symbolic learning will aid adult learners (Olson, 2007). This highlights the importance of visual literacy, as it can aid the iconic step in the learning process. This may also help explain why novice learners benefit from having visualisations, infographics, and illustrations accompany written or verbal information.

It is clear from this brief overview that visuals are increasingly important in our everyday communication and thus scholars are calling for visual literacy learning. The New Zealand government appears to have arrived at a similar conclusion, which can be seen in the TEC's reports. The TEC reported that adult literacy includes the ability to read and understand "static visual texts, such as tables, charts, maps, illustrations and photographs, and visual texts with moving images, such as movies, and TV advertisements and programmes" (TEC, 2008, p. 19). Additionally the TEC postulated that adult literacy includes the ability to write to communicate with "visual language features such as tables, charts, maps, illustrations and photographs" (TEC, 2008, p. 25) among other traditional literacy competencies. Recently, the NZ Ministry of Education stated that adult literacy is a priority area for their Tertiary Education Strategy 2014-2019, which sets out the Government's long-term strategic direction for tertiary education (Ministry of Education, 2015). This demonstrates not only a call for visual literacy at the governmental level in New Zealand, but one that is prioritised.

1.3 Visual Analysis as a Learning Means

Stokes (2002) stated that there are two major approaches for learning visual literacy skills. The first involves learners practising techniques for analysis so that they may learn to *decode* or *read* visual stimuli. The second involves learners practicing to *encode* or *write* visuals for communicative purposes. Stokes (2002) claimed that in order to be effective visual communicators, learners need to practice both. The TEC (2008) concurred, stating that both reading and writing are required to be wholly literate. However, while it is recognised here that both aspects and associated skill sets are equally important, the scope of this research is limited to reading or decoding visuals. Velders et al. (2007) stated that the steps of learning visual literacy begins with seeing followed by learning, which enables the decoding of visual messages and enables visual learning to occur. This provides the foundation to further develop communication and encoding skills. As learners must engage with decoding before encoding, or analysis before synthesis, focusing this study on decoding skills was the logical place to start. The cognitive domain classifications of *Bloom's revised taxonomy* (Krathwohl, 2002) lead to a similar conclusion. This is a classification system that can be thought of as degrees of difficulty, with learners normally needing to master each classification before moving to the next. These are remembering, understanding, applying, *analysing*, evaluating, and *creating* (Krathwohl, 2002). By applying the revised taxonomy to visual literacy, the outcome is that learners should learn *analysing* visuals before *creating* or encoding visuals as this is a lower order skill.

Why one should practice analysis as a means of learning to decode imagery is not discussed by scholars such as Stokes (2002). However, almost 100 years ago Helmholtz (1925) stated that to perceive we need a store of past experiences with visuals to draw upon. According to Helmholtz (1925), what we perceive is the result of raw sensory information, visual memories, and mental processes. Therefore, the more visual memories a person has, the more clearly they will perceive. Lester (2011) continued this line of thought when explaining why analysing images will help improve the ability to remember them.

> Without considering the image, you will not gain any understanding or personal insights. The picture will simply be another in a long line of forgotten images (Lester, 2011, p. 11).

Lester (2011) also stated that visual analysis is important, as it "is a way the mind not only engages with the outside world, but also internalizes its lessons and learns from them" (Lester, 2011, p. 11). It would therefore be fair to argue that visual analysis is both a *core skill* and a *method for learning* as it is directly tied in our mind.

One means of achieving a detailed methodological examination of a visual is to use a framework or method that ensures all the meanings and constituent parts of a visual are considered. Processes for conducting this visual analysis can be drawn from visual studies, such as semiotics, and can be very structured, such as with content analysis, or less procedural, such as with cultural studies (Leeuwen & Jewitt, 2001). All methods are however, tied to particular disciplines, which presents a problem in that it may limit the usefulness or applicability of the outcome of this research. For example, constructivist and ecological theory have very different opinions of the role our mind plays in perception, which often sees scholars entrenched in one camp or the other. To adopt such an approach would therefore entrench this research and limit any outcome to a narrow field of discipline.

As this research aims to provide a means to the process of learning rather than what specifically is to be learned, it needs to adopt an understanding of visual analysis that is inclusive, or at least aims to be. *Analysis* can be defined as a detailed methodological *examination* of the elements or structure of something, usually to inspect or explain it (Oxford Dictionaries, 2014a). Therefore, this research takes the viewpoint that visual analysis is a detailed methodological examination of the elements, structure, and surroundings of visuals, usually to interpret or explain them. “Surroundings” accounts for visual understandings that may call factors such as history, culture, context, ethics, and reception to be considered, such as those offered by authors Gombrich (1977), Lester (2011), Barnes (2011), and Howkins (2010).

1.4 A Problem with Learning Visual Literacy

As mentioned in Section 1.2, visuals are pervasive. Story (2007) went as far as suggesting that anywhere the eye can see, it is likely to encounter visual communication in the form of an advertisement. In the preceding section, it was argued that one can become visually literate by analysing visuals. These two ideas, visuals as a ubiquitous resource and visual analysis as a means of learning, raises a further line of enquiry; if the visuals we encounter everyday can be leveraged as visual literacy opportunities by practicing visual analysis, then learners’ everyday environments could potentially become learning environments where they are immersed in visual learning as they go about their day.

However, if all a learner had to do was think critically about the images they encounter, obtaining visually literacy skills would be a simple undertaking; learners could potentially learn by osmosis. This does not appear to be the case. Avgerinou and Pettersson (2011) stated that while visual meaning on a basic level can be obtained, visual literacy can only come when visual language is learned. Spalter and Van Dam (2008, p. 91) believed the same, while Brumberger (2011) demonstrated that Millennials display a lack of visual literacy before training (see Section 1.2). The TEC would seem to have arrived at a similar conclusion, as it includes visual literacy skills in its progression of literacy learning (Tertiary Education Commission, 2008).

A close examination of the literature on learning to analyse and decode imagery as a means of acquiring visual literacy skills reveals visual learning is a circular reference, which is potentially problematic. Perception and visual analysis require and are influenced by memories and experiences (Helmholtz, 1925; Jamieson, 2007), but memories and experiences are created through perception and visual analysis. Rock (1997) referred to this as a perception-perception chain of causation, where one perception enables another. This leads to a self-reinforcing loop, where by perceiving increases our store of memories, and by increasing our store of memories our ability to perceive is improved. However, when visual literacy learning is understood as a circular reference, then the novice learner encounters a dilemma. To sense and select, one must first know, but to know, one must first sense and select (see Figure 1-2). Where does a novice begin? This dilemma may explain why so few Millennials are visually literate, despite being persistently surrounded by visuals.

Lester (2011, pp. 11–12) attempted to explicate this self-reinforcing loop as a series of pedagogical assumptions on how we develop visual literacy skills:

> The more you sense, the more your mind will select. The more you select, the more you will understand what you are seeing. The more you perceive, the more you will remember, as the image becomes part of your long term memory. The more you remember, the more you learn because you compare new images with those stored in your mind. The more you learn, the more you know. The more you know, the more you sense.

Lester's (2011) excerpt resembles Huxley's (1943, p. 11) formula, "sensing + selecting + perceiving = seeing", reframed as a series of pedagogical assumptions (see Figure 1-2). The key difference is that Lester (2011) describes this formula as a circular reference.

The self-reinforcing loop can also be seen in Piaget's (1973) learning theories of *assimilation* and *accommodation*. The first, assimilation, describes how humans perceive and adapt to new information. Assimilation is the process whereby new information is fitted into pre-existing knowledge or mental blueprints (schemata). This process occurs when previously learned schemata is referred to in order to understand new information. The second process, accommodation, describes how new information is absorbed and used to alter pre-existing schemata to accommodate the new information. Essentially, assimilation adds to knowledge, while accommodation alters knowledge; both result in learning.

Piaget (1971) noted that the two processes of assimilation and accommodation are complementary; when one of these processes is triggered, so is the other. For example, to assimilate a specific photograph to memory, one must first recall the characteristics of what a photo is, and alter these characteristics (accommodation) to fit the specific photo being observed, so we may perceive it as a photo in the first place. Piaget (1971) saw the two processes as operating in harmony.

Assimilation and adaption help explain how memory is called upon, modified, and added to in the process of perception. As the two processes are mutually inclusive, they form a self-reinforcing loop that develops our cognitive abilities every time we perceive. Because the two processes come from cognitive constructivist theory (Springer, 2012), it helps to situate perception and visual literacy as a cognitive skill, corroborating the claims of Helmholtz (1925) and Lester (2011) that perception can be improved by adding to memory.

The circular reference dilemma can be overcome by providing learning support. This support can be provided by transferring or prompting the construction of knowledge, or by highlighting what to select to begin the visual learning process (see Figure 1-2). In formal learning scenarios, this support can come from an expert or peers. However, outside of formalised learning, this is more complicated as there may be no expert or peers to provide support. This may explain an earlier point that was raised; that visual literacy is not acquired by osmosis, as although learners have visuals to analyse in their environments, they lack support.

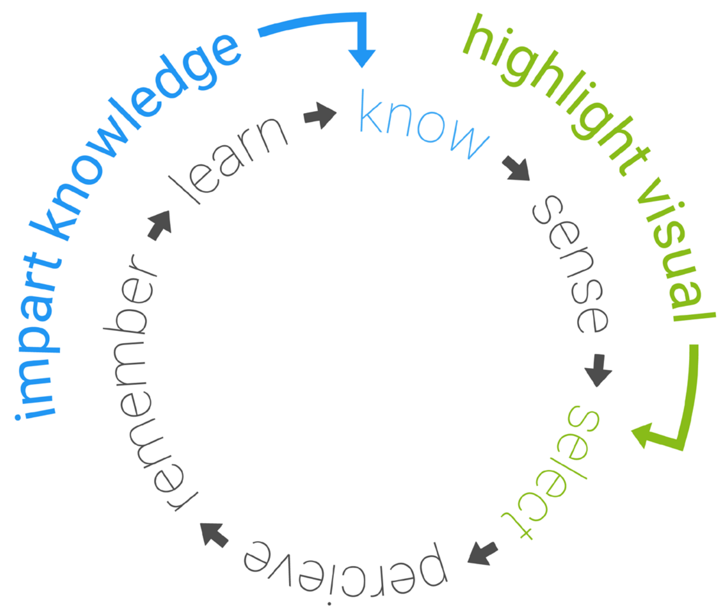


Figure 1-2: Author's adaptation of Lester's (2011) diagram of visual learning to show entry points into the circular reference system.

The idea of support is validated by a branch of cognitive constructivist theory called *social constructivism,* in particular Vygotsky's (1978) theory of the zone of proximal development (ZPD). Essentially, ZPD describes the difference between what a learner can achieve on their own, compared to if they had guidance or operated in collaboration with more experienced peers (Vygotsky, 1978). Vygotsky (1978) proposed that support should be provided so that learning can occur in an individual's ZPD, creating scaffolds to encourage further learning. Relating this back to the theory of visual literacy, it can be argued that learning from encounters with visuals is beyond a novice learner's abilities. Therefore, if there could be some way to support learners in their daily environment, learning could potentially occur.

1.5 A Potential Solution

The researcher has found little information on how that support can be provided to overcome the visual learning circular reference problem outside of formal learning scenarios. However, research does exist on supporting learners (not specifically those of visual literacy) in the form of *mobile learning* (m-learning) when physically or temporally separated from traditional or formal learning. M-learning (detailed in Section 2.3) allows learners to learn anywhere and at any time through the use of mobile devices such as smartphones (Traxler & Wishart, 2011). If one were to take the affordances of m-learning and apply them to the learning of visual literacy decoding skills, then the circular reference problem may potentially be overcome by providing anytime, anywhere support for novice learners so they can learn from everyday visuals.

However, m-learning and its umbrella field of educational technology has its critics. A key critique comes from the prevailing belief in technology to automatically enhance or improve education held by some educational technologists. While the notion that implementing new technology equates to improvements in education, Selwyn (2011) cautioned that such beliefs can also lead to an overly optimistic view of what technology can actually achieve in learning. Selwyn further warned that this perception can take on an almost evangelical viewpoint to the extent that sometimes what is reported is more a matter of faith than fact. A meta-analysis of 164 m-learning studies conducted by Wu, Wu, Chen, Kao, Lin, and Huang (2012) appeared to confirm this, concluding that m-learning studies tend only to report positive outcomes. Selwyn (2011) believed that implementing technology in learning has come to be understood as the de facto role of educational technologists. According to Selwyn (2011), as long as some technology is implemented as part of their research, the educational technologist can consider the research a success. Selwyn's (2011) stance may be extreme. It appears to be a reaction to technological determinism, the notion that technology determines and defines the nature of a society. However, at the heart of Selwyn's (2011) criticisms reside the perception that technology is taking precedence over pedagogy, perceiving a focus on tools rather than sound pedagogical practice.

Selwyn's criticism is of relevance to this research, as it is an undertaking that relies heavily on the affordances of technology. To mitigate the risk to confuse technological qualities with educational advancements, this research considered the Substitution Augmentation Modification Redefinition (SAMR) model before setting any research questions. The SAMR model is a taxonomy describing four classifications of technological and educational integration (Puentedura, 2006b). The four classifications help identify whether the technology used in learning activities is a substitute for traditional tools or whether it is used for something new that would be impossible without the respective technology (Hockly, 2012). The SAMR model queries the underlying motivation for the application of technology in learning, and is therefore focused on pedagogy. The SAMR model seeks to discourage instructional designers from focusing on directly translating into or substituting traditional learning activities with technology, and instead considers the affordances of technology and seeks to better integrate education with that technology as a means of enhancing student achievement (see Figure 1-3).

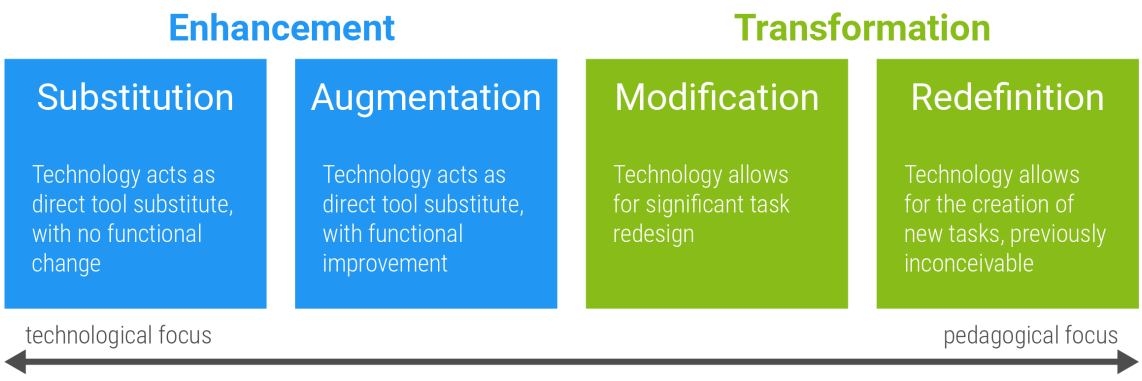


Figure 1-3: Author's visualisation of Puentedura's (2006a) SAMR model.

Substitution is where technology acts as a tool substitute, with no functional change to the learning approach (Puentedura, 2006b). According to Hockly (2012), substitution is the easiest way to implement m-learning, as learning activities are directly translated to the technology, requiring little of the original learning activity to change. This, however, means the learning activity does not really require the technology (Romrell, Kidder, & Wood, 2014), and technology is a mere add-on. Augmentation is where technology acts as a direct tool substitute, but with some functional improvement (Puentedura, 2006b). The augmentation level does not change the core learning activity, but rather seeks to enhance a traditional tool with technology that has some functional advantage (Romrell et al., 2014). Both the substitution and augmentation classifications seek to enhance learning through substituting tools.

Modification occurs when technology allows for significant task redesign (Puentedura, 2006b). Existing learning activities are purposely and significantly altered to take advantage of technological affordances (Romrell et al., 2014). One step further, redefinition is where technology allows for the creation of new learning activities previously impossible or inconceivable (Puentedura, 2006b). Redefinition is about creating new learning activities that are purpose-built to fully leverage technological affordances, with the aim of significantly enhancing learning (Hockly, 2012; Puentedura, 2006a). The modification and redefinition classifications move beyond simple learning aids and seek to transform learning by fully leveraging a technology's affordances.

Puentedura (2006a) argued that transformational learning, specifically redefinition, is a best practice in computer-mediated learning, as it has the greatest impact on transforming and optimising learning. His argument is, however, not empirically supported, as there is little data to back up the claim. Instead, the argument is conceptual. Puentedura (2006a) believed that by integrating technology in a manner more considerate of its affordances, an instructional designer will more readily consider the learning and teaching opportunities rather than become distracted by technology's "bells and whistles". Hockly (2012, p. 3) had a similar view, stating "it is not the technology itself that enhances teaching or learning, but rather the use to which it is put". Hockly (2012) believed m-learning reaches its full potential at the transformational levels, particularly redefinition.

The SAMR model goes some way towards understanding Selwyn's (2011) critique that educational technology research tends to be technocentric to its detriment. At the enhancement level, educational activities remain virtually unchanged, as focus is placed on technology. The educational technologist's intervention at this level sees an analogue tool swapped for a digital one. This is a pitfall this research aims to avoid, as substitiutional technologies offer little improvement to learning. Redefinition is of particular interest to this research, as it is about creating new, previously impossible or inconceivable, learning, with the aim of transforming learning (Hockly, 2012; Puentedura, 2006a). With this understanding, this research established an approach that positions pedagogy first. This is followed by a practical component consisting of technological implementation of any pedagogical considerations forwarded by this research. The practical component addresses a point in Selwyn's (2011) critique, that educational technology can be overly optimistic in regard to what is achievable. This approach saw the creation of sequential research questions, as discussed in the next section.

1.6 Research Questions

The research undertaken is an exploration involving conceptual and practice-based components, using heuristic inquiry as an overarching methodology. This research explores ideas rather than test hypotheses, and so begins with a research direction rather than explicit questions, which is a common tenet of heuristic inquiry. The research direction is:

> **Exploring how the visuals one encounters every day can be leveraged as opportunities for learning visual literacy.**

The research then explores the research direction from two angles; first, conceptually and second, through practice. This study's research questions reflect the combination of the conceptual and practice-based approach. The first research question is:

> **RQ1: How can everyday encounters with visuals be leveraged as visual literacy learning opportunities by providing learning support?**

The first question begins by building on existing knowledge, consolidating and synthesising what is already known but scattered and fragmented across several currently unconnected domains. Exploring this question will lead to the development of a tentative learning model consisting of a set of pedagogical assumptions, which describe how to support novice learners so they may become visually literate. The practical component of the research then seeks to implement this learning model, leading to the second research question:

> **RQ2: How can the learning model be implemented as a smartphone app?**

The second research question is explored through the creation of a prototype for a mobile application (app). The effectiveness of the prototype is then tested to potentially refine or validate the prototype and the learning model on which the prototype was based.

1.7 Significance of the Research

The findings of this study will be of benefit given the important role that visuals play as a medium for communication today. The increased need for the average person to communicate using visuals justifies the need for effective visual literacy learning means (Marcum, 2002; Hanifan, 2008). Despite the need for visual literacy education, Arnheim (1969), Dondis (1973), and Bleed (2005) argued that formal education has been slow to respond. Thus, this research explores informal learning, so that outcomes of this research have the potential to be implemented without the need for adoption by formal education.

For visual literacy learners, the approach to learning derived from this research will allow them to use contingent learning encounters with visuals from their environments as learning opportunities. This contingent style of visual learning may allow for visual literacy acquisition to occur as a by-product of a learner's daily interaction with their environment, converting a learner's environment into a visual learning environment. For the researcher, the study will help uncover areas critical to the education of visual literacy in informal settings, which is an area that is often overlooked by researchers. Thus, a new model of visual literacy learning may be arrived at. Further, the practice-based component of this study may produce software solutions that would aid users' visual learning. This study also provides an example of best practice in the implementation of mobile learning, leveraging informal, collaborative, and authentic learning.

1.8 Lessons from A Past Study

This study is not the first to note a lack of scholarly knowledge regarding informal learning of visual literacy skills. Paris and Hapgood (2002) also noted this gap and flagged informal learning of visual skills as a potentially productive area for future research. The lack of research in this specific branch of visual literacy learning is likely due to broader issues regarding the fluid and contested nature of the concept of visual literacy (discussed further in section 2.2). This line of argumentation can be seen in a seminal article by Brill, Kim, and Branch (2007) that reports the outcome of a Delphi study they conducted with the International Visual Literacy Association (IVLA). The study aimed to develop a consensus definition of visual literacy from among visual literacy scholars and practitioners. However, according to Brill et al. (2007), the study produced a definition that is too broad to be useful. Further, Brill et al. (2007) criticise the study's consensus definition and the IVLA's definition of visual literacy of lacking the level of detail needed for educational researchers to use. Such admonitions from a leading visual literacy research association regarding research on visual literacy learning may see researchers avoid the subject altogether. This may explain why there is a limited pool of studies for this research to draw upon.

Despite potential challenges in researching visual literacy and its learning, there are studies that have done just that. However, the majority appear to be confined to exploring an isolated aspect or specific practice of visual literacy and its learning, a problem also noted by McMaster (2015) in a review of visual literacy literature. Of those studies that take a broader view of learning visual literacy related skills, only a small selection explores informal learning, which is again narrowed to only a few that explore developing ICT solutions. One such study from this narrow scope is called "TagAlong".

TagAlong explores situated and informal learning so that observations in new or unknown real world environments can be harnessed as learning opportunities (Greenwald, Khan, Vazquez, & Maes, 2015). Thus, the impetus for TagAlong is similar to the current study's. The TagAlong study explored the creation of a heads-up display m-learning application that was used in a trial to learn about art. The study had an emphasis on the technology, exploring the possibilities of Google Glass as a heads-up display for learning. TagAlong allowed a learner to open a dialogue with experts to discuss what they are seeing in their environment. This dialogue provided an opportunity to learn.

While the TagAlong study makes amicable contributions to scholarship regarding remote learning, a close examination of the TagAlong study reveals three issues. The first becomes apparent when critiquing TagAlong through the lens of SAMR. The system replicated a traditional expert and novice learning dynamic akin to an apprenticeship, with a functional improvement as the expert can be remote. A functional improvement classifies TagAlong as an augmentation within the SAMR model (Puentedura, 2006b). While the augmentation classification is an improvement, the SAMR model describes this as one that does not warrant high cost or effort (Puentedura, 2006b). The TagAlong system would have required each learner to spend approximately $1500 USD on a pair of Google Glass (Swider, 2017), and the remote expert would most likely need some remuneration also. This is a high cost for a single functional improvement over existing practice. The second issue is that the TagAlong system is not scalable, as it relies on one-to-one communication between expert and novice. The third issue is that of agility. The study's approach committed early to a specific technology, Google Glass. This technology was pulled from the market in January 2015 (Luckerson, 2015), before the study was released later that year. By focusing first on a specific technology and its development, the study lacked the agility needed to change direction when signs of Google Glass's redundancy became apparent. The result was that the technology was already redundant at the time of the study's publication.

The TagAlong study adopted an iterative design process, consisting of outlining design goals, creating a UI, noting usability issues in exploratory usage, improving the UI, and then conducting a pilot study (Greenwald et al., 2015). The use of iterative design appears a common practice regarding research dealing with educational technology and can be seen in practice-based approaches such as *educational design research* (EDR) (McKenney & Reeves, 2012) or *action research* (Huang, 2010). EDR uses cycles consisting of analysis, design, and evaluation (McKenney & Reeves, 2012) whereas action research uses cycles of action and reflection (Huang, 2010). These different iterative methodologies appear to share common roots in Schön's (1983) seminal work regarding "reflection-in-action". Schön (1983) described how professionals solve problems, draw on tacit knowledge to do so, and how this may be applied in research (discussed later in section 3.4.1).

One caution in regard to the aforementioned iterative approaches is how they conduct ideation. For example, TagAlong began with design goals consisting of feature sets regarding technology. This goes against user centred-design (UCD) which is the prevailing professional practice in software development. UCD argues that traditional software design practices focused too heavily on systems or technologies, and instead should focus on user requirements so that outcomes meet the users' needs and are therefore useful (Vredenburg, Mao, Smith, & Carey, 2002) (discussed further in section 3.5). By not adopting industry practice, TagAlong's approach would appear at odds with Schön (1983) and methodologies which seek to mimic professional practice in research settings. Had UCD procedures been followed, Google Glass would most likely have been delimited from the study as so few people purchased this technology. Further, beginning with such clear design goals is ambitious if one accepts Brill et al.'s (2007) argument that there is not enough clarity surrounding the concept of visual literacy for researchers to explore its learning. How can one begin with such clarity in a field stated to lack an operational definition? Schön (1983) believed that in such cases, practitioners draw on creative processes and tacit knowledge to make intuitive leaps in areas of uncertainty (discussed further in Chapter 3). Given such uncertainty surrounding visual literacy and its learning, utilising a creative research approach that can draw on tacit knowledge may provide this research a means to make intuitive leaps that can bridge gaps in visual literacy learning knowledge.

While this brief review of TagAlong has been critical, it should be noted that the researcher has great respect for the research. TagAlong has ventured into an area that is murky, but also worthwhile. While it may not have had the desired outcome, it has provided a number of lessons this research can benefit from: 1) aim for SAMR's redefinition level to warrant investment of time and money, 2) propose an outcome that is scalable, 3) incorporate agility and flexibility into the approach to account for potentially changing technology, and 4) use a creative approach that can draw on tacit knowledge to make intuitive leaps. An aside lesson is that this current research ventures into similar murky territory as TagAlong, and is therefore likely to have some limitations. However, the researcher believes the pursuit worthwhile as any potential shortcomings in this research may provide further lessons for those who follow.

1.9 Thesis Structure

This first chapter introduces the aims of the study, provides the background for the research, outlines the research questions, and clarifies the significance of the study and potential outcomes.

Chapter 2, the literature review, establishes the theoretical framework for the research. The first section defines visual literacy. The second explores m-learning in the context of visual learning. Challenges of m-learning are then reviewed to posit the practice-based components of this study. Constructivism, collaborative learning, and rhizomatic learning are introduced as relevant concepts for visual m-learning.

Chapter 3, the methodology and research design, describes the methodological framework of the research. The chapter introduces practice-based research, heuristic inquiry, and user-centred design. These components are then synthesised into a tailor-made research design consisting of three stages – stage one: explication of a learning model, stage two: prototype an app based on the learning model, and stage three: test and refine the learning model and prototype app.

Chapter 4, the learning model and prototype, reports the outcome of stages one and two of the research. The first part of the chapter presents a tentative learning model for visual literacy learning from one's environment. The second part presents a low-fidelity prototype for an app that is based on the tentative learning model.

Chapter 5, the results section of the thesis, reports the outcome of the usability testing sessions. The reporting is divided among the sections of the usability testing sessions, namely, the warm-up questions, the scenarios and their tasks, and the interview questions.

Chapter 6 discusses the results reported in Chapter 5. The discussion is divided between the learning model and prototype app. The learning model is discussed using its pedagogical assumptions, with each either demonstrated as purposeful or refined in consideration of the results. The prototype app is then discussed to verify whether it meets the aims of this study. The apps usability issues are also addressed by providing recommendations on how they may be overcome.

Chapter 7 concludes the research. The study's aim and research questions are revisited and compared to the research outcomes. A summarised version of the refined learning model is presented to answer RQ1. A link to a functional version of the high-fidelity prototype is provided to answer RQ2. The chapter includes the study's limitations, implications, and recommendations for further research.

Chapter 2: Literature Review

2.1 Introduction

The introduction chapter identified that learning visual literacy decoding skills may be problematic when separated from traditional learning materials or support (Section 1.4). M-learning may overcome this problem as it allows learners to learn anywhere and at any time using mobile devices such as smartphones. Therefore, in this chapter, m-learning is reviewed as a means of learning visual literacy skills. As the review of m-learning is contextualised by learning visual literacy, the review begins by briefly defining visual literacy and its five conceptual components: visual perception, visual language, visual learning, visual thinking, and visual communication. M-learning is then reviewed using its seven related affordances: ubiquitous learning, informal learning, contingent learning, situated learning, authentic learning, context-aware learning, and personalised learning. Challenges of m-learning are examined to position the practice-based component of this research. Because m-learning does not adhere to any specific pedagogical model, the review then turns to pedagogical models that are suitable for this research. Constructivist learning is noted in the previous chapter as having an association with visual perception and visual learning, notably the concepts of accommodation and assimilation (see Section 1.5). This chapter therefore reviews cognitive and social constructivist learning. Collaborative learning is then considered as a means of providing support. Last, rhizomatic learning is surveyed as it provides an understanding of how learners and their support may organise themselves in an informal learning setting.

2.2 Defining Visual Literacy

Visual literacy lacks a widely accepted definition, and as a consequence lacks a singular cohesive theory (Braden, 1996). Visual literacy’s lack of a shared definition is most likely a result of the multitude of disciplines each wanting to define visual literacy in relation to their own unique domains of knowledge (Avgerinou & Ericson, 1997; Avgerinou & Pettersson, 2011). While progress has been made to ameliorate the disparate definitions, visual literacy is still a relatively new discipline trying to find its feet; a problem that many new emergent disciplines have. The lack of cohesion in visual literacy scholarship has problematised the definition of visual literacy, what its facets are, and how they relate. In recognition of the lack of clarity, this section attempts to settle on an understanding of visual literacy that is suitable for this research.

One of the first contemporary definitions of visual literacy was offered by Debes (1969, p. 69):

> Visual Literacy refers to a group of vision-competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences. The development of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person to discriminate and interpret the visible actions, objects, symbols, natural or man-made, that he encounters in his environment. Through the creative use of these competencies, he is able to communicate with others. Through the appreciative use of these competencies, he is able to comprehend and enjoy the masterworks of visual communication.

Debes's (1969) definition is often viewed as problematic, as it focuses on competencies – that is, what a visually literate person can *do*, not what visual literacy *is*. It is also quite long, providing more of a description than a definition. While these factors might make Debes's (1969) definition unsuitable for that purpose, it is useful for this research as the competencies described can be translated into learning outcomes. However, a more concise definition will aid in identifying what is key to visual literacy and help to bridge ideas germane to the acquisition of visual literacy. Hortin (1983, p. 99) offered another, more concise, definition:

> Visual literacy is the ability to understand (read) and use (write) images and to think and learn in terms of images, i.e., to think visually.

Although old, Hortin's (1983) definition is still the most widely in use. Further, this definition shares common tenets with other popular visual literacy definitions from the past 30 years, which Avgerinou and Pettersson (2011) summarised as: a) a visual language exists, b) visual language parallels verbal language, c) it is a cognitive ability that also draws on the affective domain, d) skills of reading, writing, and thinking visually are identified, and e) these skills are learnable. Also, worth noting is that John Hortin was an educational technologist. Therefore, the theoretical underpinnings of John Hortin's work, including his definition, align to this research which is an undertaking in educational technology. For the preceding reasons, this research adopts Hortin's (1983) definition of visual literacy.

Avgerinou and Pettersson (2011) stated that visual literacy is comprised of five conceptual components: visual perception, visual language, visual learning, visual thinking, and visual communication. These components are the result of analysing recurring themes in definitions and descriptions of visual literacy over the past forty years (Avgerinou & Pettersson, 2011) and are present or implied in Hortin's (1983) preceding definition. These components' boundaries are fluid and indistinct, overlapping each other to comprise visual literacy as can be shown here:

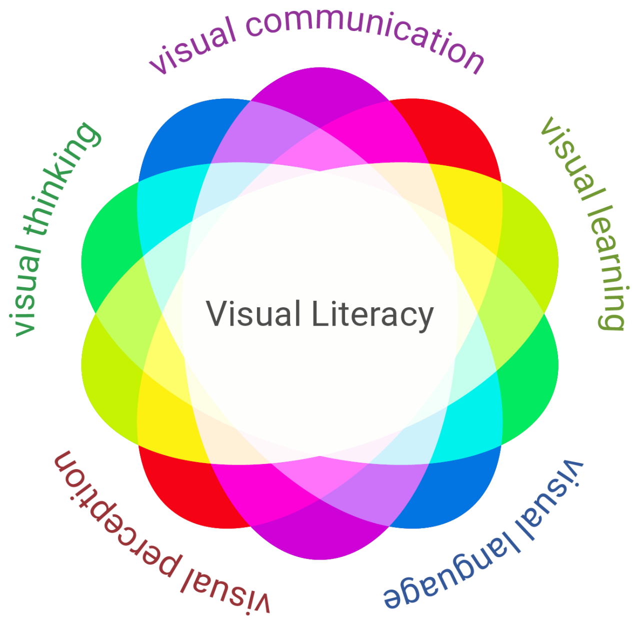


Figure 2-1: The overlapping conceptual components comprising visual literacy. Author's original composition.

Barnes (2011, p. 3) defined visual communication as "the process through which individuals — in relationships, organizations, and cultures — interpret and create visual messages in response to their environment, one another, and social structures". This definition has many similarities to the definition for visual literacy provided by Hortin in 1983. Both share the notions of reading and writing. Both acknowledge the existence of a visual language as a mode of communication. However, Barnes's (2011) definition differs in that it includes "culture", as it references an understanding of visual language through semiotics (the study of signs). Visual thinking and visual learning are not included in Barnes's (2011) visual communication definition, and it can be argued that they are omitted as they are separate, independent, components of visual literacy. Another difference with the visual communications definition is that it implies application of skills for communicative interchange. These differences suggest that visual literacy operates at a higher conceptual level, and is concerned with critical understanding, thinking, and learning, while visual communication refers to communication with visuals and how they are used to create understanding between people. It can therefore be rationalised that visual communication is the application of reading and writing referred to in visual literacy's definition and is therefore subordinate.

Hortin (1983) did not explicitly state that there is a *visual language,* but rather implies this in his visual literacy definition as he assumed that there must be some language or code for people to read or write images. Language is defined as a system of communication (Oxford Dictionaries, 2015b), and visual language is a specific system that allows us to communicate using visuals (Ausburn & Ausburn, 1978). This research uses this definition of the term "visual language”. In this sense, visual language is similar to verbal language in that it can be considered to have (visual) analogies to semantics, syntax, morphology or grammar, and rhetoric or composition (Horn, 1998). While communicating with visuals and the idea of visual dialects are nothing new, visual language as we presently understand it has developed out of the amalgamation of visual “sublanguages” such as diagramming, cartooning, advertising, graphical interfaces, and countless others (Horn, 1998). This visual system (or language) can be described in many ways, such as by its visual components or marks; or analytically such as with semiotics; theoretically such as with gestalt theory, cognitive theory, ecological theory; or even by application, such as cartography or user interface design.

Avgerinou and Pettersson (2011) noted the recurring theme of *visual thinking* in the definitions of visual literacy they reviewed. Hortin (1994, p. 26) placed particular emphasis on visual thinking, stating that, “visual literacy is really training for visual thinking”. However, neither Hortin (1994), or Avgerinou and Pettersson (2011) provide a clear definition of what visual thinking is. This lack of definition can be traced back to the scholarship of Arnheim (1969), an early contemporary proponent of visual literacy in education. Arnheim (1969) argued that the term visual thinking is misleading, as all thinking is sensorium in nature.

Arnheim believed that there should be no dichotomy between thinking and visual thinking (or any other type of thinking) stating, “The thought elements in perception and the perceptual elements in thought are complementary. They make human cognition a unitary process which leads without break from the elementary acquisition of sensory information to the most generic theoretical ideas" (Arnheim, 1969, p. 153). From this we can see that Arnheim (1969) is not trying to argue against visual thinking, but rather state its inseparable nature in the thought process. This argument was most likely Arnheim’s reaction to the separation or lack of importance placed on visual literacy in traditional education and his desire to integrate the two. This desire can be seen in his following statement; “To try to establish an island of visual literacy in an ocean of blindness is ultimately self-defeating. Visual thinking is indivisible” (Arnheim, 1969, p. 307). Lacking a clear and concise definition, the term visual thinking can be understood at a rudimentary level by combining the two definitions for ‘visual’ and ‘thinking’ which results in “to direct one’s mind’s sight towards someone or something; to use one’s mind’s sight actively to form connected ideas” (Oxford Dictionaries, 2014b, 2014c).

The field of psychology separates between the sensation that results from excitation of sensory receptors and perception, which is defined in the Oxford Dictionary of Psychology as a “sensory experience that has been interpreted with reference to its presumed external stimulus object or event” (Colman, 2014, Chapter 1). Huxley (1943), Helmholtz (1925), Lester

(2011) and Jamieson (2007) define *visual perception* similarly in terms of vision, stating that perception is the result of a cognitive act where the mind attempts to make sense of the raw visual data sensed by one's eyes.

Huxley (1943, p. 11) situates perception in the formula, "sensing + selecting + perceiving = seeing". This formula accounts for how the mind and body function together so that one may see. This appears to be a summary of the earlier work of Helmholtz (1925), who made the same points, just less concisely. Jamieson (2007) understood perception in a similar way to Huxley and Helmholtz, providing a newer framework for perception which consists of three stages, namely the optics of viewing, processing, and psychology. In Huxley's (1943) formula, "sensing" is the act of receiving light through one's eyes. Sensing can be thought of as the physical part of the process, engaging the eye and nervous system. Next in Huxley's (1943) formula is selecting, which is to filter or single out parts of one's field of vision. This is both physiological, as the eye only has a small area that can be in focus at any given moment, and psychological as there is usually something of interest in one's field of vision which the mind wishes to discriminate. Jamieson's (2007) framework has combined Huxley's (1943) two ideas of "sensing and selecting" as the first stage in his model, which he refers to as "seeing". Jamieson (2007) then inserted an additional stage that Huxley's (1943) model was missing, which deals with the mechanisms of the brain designed to process visual information. Jamieson (1943) acknowledged that this process may be affected by people's cognitive predispositions because of previous visual learning. The third stage for both models is psychology and visual perception. Huxley believed this is where the mind becomes fully engaged, interpreting received data into external physical objects. Jamieson (2007) also believed this but built on the idea to add that the mind uses mental frameworks acquired from social and cultural conditioning. Both understandings of visual perception can be referred to as a *Helmholtzian* or *Constructivist* stance (Norman, 2002).

As visual perception is defined as a cognitive act by Lester (2011), Jamieson (2007), and Avgerinou and Pettersson (2011), visual perception can be described as a means by which we begin to internalise visuals. This internalisation results in *visual learning*. One means to promote this internalisation is through conducting visual analysis, which is discussed in the introduction chapter (Section 1.3). As visual learning is a key tenet of this research, this chapter further reviews visual learning in the context of m-learning and existing pedagogical models.

2.3 M-Learning

Mobile learning (m-learning) is a relatively new field that has only received more widespread attention since 2005 (Crompton, 2013; Traxler, 2011a). To argue any conclusive definition of what this field is would be premature, as the technology used and pedagogical underpinnings are still developing (Crompton, 2013). This has resulted in many competing definitions of m-learning, as scholars regularly update or forward new definitions to describe m-learning (Gikas & Grant, 2013). Traxler (2011a, p. 4), a respected authority in m-learning, appeared to have recognised this as an issue and quipped that m-learning is, “probably just learning with mobile devices”.

Notwithstanding a lack of consolidation of the concept of m-learning, one of the most widely cited definitions was offered by Sharples, Taylor, and Vavoula (2007, p. 4) as “the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies”. This definition has an emphasis on conversations, which Crompton (2013) argued limits, by its dictionary definition, m-learning to oral exchanges. While it can be argued that conversations could have been intended to mean interactions in general, a definition that is more inclusive and flexible is desirable for this research which deals with competencies of visual literacy. Therefore this research will be adopting the rewording of Sharples et al. (2007) definition offered by Crompton (2013, p. 83), of “learning across multiple contexts, through social and content interactions, using personal electronic devices.”

The primary, and probably the most obvious assumption of m-learning, is that learners are on the move. By taking advantage of learning opportunities offered by mobile devices, learning does not need to occur at a fixed or predetermined location (Wu et al., 2012). Learners learn across both space and time, as they take knowledge from one location or time and either revisit it, or apply it to another (Sharples et al., 2007). By applying ideas and strategies gained in earlier experiences and different contexts, learners build frameworks for lifelong learning (Sharples et al., 2007). M-learning’s ability to journey with learners across time and space allows it to be used ‘everywhere and every time’ (Georgiev, Georgieva, & Smrikarov, 2004). This leads to learning that can be more context-aware, authentic, and situated in a learner’s surroundings (Gikas & Grant, 2013), which is an attractive proposition when considering how learners can learn from life’s everyday imagery when they are separated from traditional learning support. Applying m-learning to learning competencies of visual literacy may afford learners more opportunities to learn as they would have persistent access to some form of support, which has the potential to turn everyday life into a visual literacy learning opportunity. Therefore, the next sections will review the affordances of m-learning in the context of this research project's aim to aid novice visual literacy learners with competencies to decode imagery. This is done using five affordances of m-learning that can provide new learning opportunities as highlighted by Traxler (2011a), namely, contingent learning, situated learning, authentic learning, context-aware learning, and personalised learning. Also, while not strictly m-learning, the affordances of ubiquitous and informal learning are discussed as the two are commonly associated with m-learning and provide insight on how to learn from one's environment.

2.3.1 Informal learning

Informal learning is not defined as part of m-learning or vice versa. However, as the intention of this research is to apply m-learning in informal learning scenarios (a learner's everyday environment), it is a necessary aspect to discuss. Informal learning can be thought of as a reaction to formal learning; informal learning tries to be what formal learning evades, neglects, or what is beyond its scope (Drotner, 2008). Schugurensky (2006) believed if formal education covers preschool through to graduate studies, and non-formal education is any organised educational activity outside of formal education, then informal learning can be loosely defined as "everything else". This makes explicating what informal learning is challenging, as "everything else" is vague. Nevertheless, Rogers (2006, p. 4) attempted a description of informal learning, stating that it is:

> …a natural activity which continues at all times; it is highly individualised, contextualised… It is almost always concrete, limited to the immediate need; it is always embedded within some other activity. […] It is our own individual way of making sense (meaning) of life's experiences and using that for dealing with new experiences. ...like breathing, it is the (mental) process of drawing into ourselves the natural and human environment in which we live... and using it to build up (develop) ourselves.

Rogers' (2006) statement aligns informal learning to the goals of this research, as this type of learning can be embedded in other activities. This would allow for visual literacy learning to be embedded into a learner's daily activities. Indeed, Rogers believed that informal learning takes place while at home, in the community, at work, and in leisure.

Schugurensky (2000) postulated that informal learning occurs in three ways: self-directed which is conscious and intentional; incidental which is conscious although not intentional; and socialisation or tacit learning, which is neither a conscious act nor intentional. These three classifications can be applied to Rogers (2008) scholarship on informal learning of reading and writing to help understand where the visual literacy skills learned from one's environment would be placed. While Rogers (2008) was referring to traditional literacy, most of his ideas can be translated to visual literacy learning, as both visual literacy and traditional literacy deal with the codification of messages and therefore are a form of symbolic learning. Rogers (2008) noted that language is first learned informally through the use of language without structure, experimentation, trial and error, with social scaffolding for reinforcement and correction until the cultural means of communication are mastered. Much of this learning takes place as learners engage in some other activity and happens subconsciously, thereby defining it as incidental or social learning. However, Rogers (2008) noted that learning also takes place when adult learners seek out personal assistance from their community, which is a conscious and intentional form of learning and therefore self-directed. This view is shared by Merriam, Baumgartner, and Caffarella (2007), who said that learners will seek assistance by pooling resources in pursuit of informal learning. This research may not be able to address tacit visual literacy learning, which is not a conscious act nor intentional, as it seeks to support leaners using m-learning, who would therefore have had to consciously access some form of technology to begin learning. It will, however, be able to address the conscious aspects of incidental and self-directed informal learning. Given this, there are two key concerns for leveraging everyday visuals from one's environment in informal learning settings; the question of how to provide assistance for self-directed learning through some form of community (see Section 2.5) and the question of how to leverage incidental encounters with visuals as learning opportunities.

Informal learning has its critics, however, as there is a lack of evidence on why, where, when, how, and what is learned under informal conditions (Drotner, 2008). Drotner's (2008) critique is relevant in so far as informal learning by its very nature is not intended to be assessed, and consequently there is little evidence collected that supports learning outcomes. Additionally, informal learning can be highly personal (Boud & Falchikov, 2006), meaning learning can vary from person to person.

2.3.2 Ubiquitous learning

Ubiquitous learning (u-learning) shares some aspects of m-learning. These shared aspects can be seen in the scholarship of Yang (2006, p. 188):

> The ubiquitous learning environment provides an interoperable, pervasive, and seamless learning architecture to connect, integrate, and share three major dimensions of learning resources: learning collaborators, learning contents, and learning services.

Yang's (2006) excerpt touches on or assumes the use of the four key aspects of m-learning: pedagogy, technological devices, context, and social interactions (Crompton, 2013). The key differences are that u-learning does not specify mobile means of learning as m-learning does, but rather pervasive learning that is everywhere and available any time. This difference is essentially the "ubiquitous" in ubiquitous learning. This ubiquitous aspect is one potential means to provide learning embedded in a learners' everyday environment. Therefore, this review focuses on the component of ubiquity offered by u-learning and how it may be of use to this research.

An easy way to arrive at an understanding of ubiquitous learning is to examine its roots. The definition of ubiquitous is "present, appearing, or found everywhere" (Oxford Dictionaries, 2017a). Ubiquitous computing, of which u-learning is enabled by and born of (Zhao, Wan, & Okamoto, 2011), was proposed by Weiser (1993). Weiser (1993, p. 71) stated that the goal of ubiquitous computing is the "nonintrusive availability of computers throughout the physical environment, virtually, if not effectively, invisible to the user." He added "ubiquitous computing will integrate information displays into the everyday physical world" (p. 71). Therefore, u-learning is ever-present computer-mediated learning that integrates information into the everyday physical world in a nonintrusive manner. This ubiquity is one aspect that separates u-learning from m-learning; u-learning technology and its use become less apparent, disappearing as it is embedded into the background of daily life (Park, 2011).

Hwang, Tsai, and Yang (2008) stated that the ideal u-learning environment would be achieved when computing, communication, and sensor devices were embedded and integrated into learners' daily lives in order to make learning immersive.

U-learning is often discussed in conjunction with context-aware learning (see Section 2.3.5), by authors such as Yang (2006), who argued that u-learning's effectiveness and efficiency relies on the context. This argument has a sound basis; for u-learning to be ubiquitous, it must integrate with the environment. This integration can only occur if some measure of the environment's context is understood. The role of context-awareness in u-learning is to detect and adapt to the ubiquitous environment in its changing contexts (Zhao et al., 2011). The varied contexts may include the learner's state, educational activity, environment state, or system (Zhao et al., 2011).

2.3.3 Contingent and situated learning

Contingent mobile learning and teaching, according to Traxler (2011a), allows learners to react and respond to their environment and to their changing experiences. *Contingent* is defined as "subject to chance" (Oxford Dictionaries, 2015a, sec. 1), therefore *contingent learning* can be thought of as learning that is dependent on chance learning opportunities. This affords flexibility so that learning opportunities do not have to be pre-determined (Traxler, 2011a). Learners can explore and follow hunches, rather than exclusively follow planned lessons

(Traxler, 2011b). Contingent mobile learning therefore is m-learning's take on incidental informal learning (described earlier in Section 2.3.1) as it is conscious but not intentional.

Traxler and Wishart (2011) state, that contingent learning allows for learning to occur in the field. Learning in the field is often referred to as *situated learning* by m-learning scholarship. Situated learning is where learning takes place in surroundings that make learning meaningful (Traxler, 2011a). Situated learning promotes learning in an authentic context and culture (Herrington, Mantei, Herrington, Olney, & Ferry, 2008).

Anecdotal evidence suggests that contingent and situated learning are not a new idea in the education of visual literacy. This anecdotal evidence is understandable given the pervasive nature of imagery in contemporary society, even in private spaces (Avgerinou & Ericson, 1997). This pervasive nature means that there is a high possibility of contingent encounters with examples of visual communication situated in a learner's environment at any given moment. However, as noted in the introduction, exposure to visuals does not necessarily result in learning (Brumberger, 2011). Therefore, it would appear that some contingent encounters with examples of visual communication result in learning while others do not.

The proposition that some contingent encounters with visuals result in learning while others do not, may be explained by the role of *memory* in perception. As noted in Section 1.4, memory affects our ability to perceive, with more memories or prior experience resulting in an increased ability to perceive (Helmholtz, 1925; Jamieson, 2007). Essentially, this means some visuals will be noticed while others will not, and if a contingent learning opportunity is not noticed then it cannot be engaged with or learned from. Constructivists believe that what one experiences is based on their mental constructs, knowledge, or schemata projected onto the world (Leidner & Jarvenpaa, 1995). This is explained through several principles, namely: salience, habituation, normalising, and dissonance.

Salience refers to how people are more attuned to notice stimulus if it has some meaning to them based on memory or cognitive processes (Bloomer, 1990). This aligns with the circular-reference of visual literacy learning (see Section 1.4), as prior knowledge guides one to select a visual to begin the learning process (Lester, 2011). Salience therefore may account for how some contingent learning opportunities may be leveraged by this research; learners may select visuals to analyse by their own volition as a result of the visuals being salient to them. As existing prior knowledge makes such visuals salient to a learner, this would represent a chance for what Piaget (1973) described as accommodation by refining or altering pre-existing schemata and potentially the assimilation of anything unknown to form new schemata.

The concept of salience also reinforces a point made in the introduction (Section 1.4), that novice visual literacy learners lacking prior experience may struggle to learn from visuals in their environment. This can be said as novice learners lacking memories or prior experience may fail to see contingent learning opportunities or perceive them in a manner that is not germane to learning, as these visuals are not salient.

Further to visuals not being salient, habituation, normalising and dissonance may account for visual literacy learners ignoring contingent learning opportunities in their environments. Habituation refers to how our minds tune out stimulus that is constant, repetitious, and predictable (Bloomer, 1990). An example of habituation would be how a sighted person will not perceive their own nose, even though it is always in their field of vision. Normalising is a phenomenon where our mind corrects, ignores, or normalises unexpected irregularities. Bloomer (1990, p. 14) notes, “whenever possible, perception encourages us to experience what is probable in a situation, rather than what is possible. In this way, our perceptual systems simplify our worlds and keep it predictable.” It is this phenomenon that allows us to overlook obvious spelling mistakes, or not notice someone’s new haircut. Dissonance refers to how two or more perceptions may conflict with each other, or how the mind prefers to focus on one thing at a time. The mind cannot tune these two perceptions out so instead they cause conflict making it difficult to concentrate on, or accept, one message over the other (Bloomer, 1990; Lester, 2011). An example of dissonance would be the struggle or frustration one may experience when trying to watch TV with the radio on.

Salience, habituation, normalising, and dissonance may explain how contingent learning opportunities can go unseen or even ignored by learners, and may help explain why people do not learn visual literacy from mere exposure to visuals. Therefore, there needs to be some support for novice visual literacy learners to engage with contingent learning opportunities in their environment that they do not notice on their own volition. Referring back to Figure 1-3, it was noted that this support can be provided through peers or experts imparting knowledge or highlighting visuals. Therefore, for novice visual literacy learners to learn from contingent learning opportunities situated in their own environments, they may require support in the form of highlighting and the imparting of knowledge.

2.3.4 Authentic learning

Authentic learning in m-learning is “where learning tasks are meaningfully related to immediate learning goals” (Traxler, 2011a, p. 6). Herrington, Oliver, and Reeves (2003) conducted a meta-analysis of authentic learning’s various definitions which resulted in a list of ten core characteristics. These are: authentic activities that have real world relevance, are ill-defined, comprise complex tasks to be investigated by learners over a sustained period of time, provide the opportunity for learners to examine the task from different perspectives, provide the opportunity to collaborate, provide the opportunity to reflect, integrate and apply across different subject areas leading beyond specific domain knowledge, seamlessly integrate with assessment, create polished products valuable in their own right, allow competing solutions and a diversity of outcomes.

The ill-defined nature of authentic learning creates opportunities for learners to help decide what is learned (Herrington et al., 2003; Nicaise, Gibney, & Crane, 2000). This sees intrinsic forces (such as personal projects) play a role in learning, allowing learners to pursue their own learning goals (Nicaise et al., 2000), and therefore is open to personalised learning. As a result, assessment should not be regulated by external forces such as grades or points but instead by the learners themselves (Nicaise et al., 2000). The introduction chapter of this thesis established visual literacy to be a large field understood differently by various disciplines (see Section 2.2) therefore, learning of visual literacy needs to account for a multitude of perspectives. Authentic learning's ability for learners to pursue their own learning goals and influence assessment is one means of accounting for the multitude of perspectives. This research, as a form of informal visual literacy learning, should account for aspects of authentic learning. This also flags the importance of personalised learning in visual literacy m-learning, which is discussed in the following section.

Situated learning is closely linked to the idea of authentic learning in m-learning, as situated learning allows learning to take place in locations that are immediately tied to learning goals (Naismith, Lonsdale, Vavoula, & Sharples, 2004). While situated and authentic learning are not mutually inclusive, both Traxler (2011a) and Naismith et al. (2004) noted their close relationship as one can often lead to the other in m-learning.

Another advantage of authentic learning is that it allows learners to be enculturated into a discipline (Lombardi, 2007), that is, to learn the requirements, behaviours, and values of a discipline. In this research, the discipline would be that of visual practitioners. Lombardi (2007) claimed that the learning process of enculturated individuals develops skills that allow them to recognise whether a problem is important, or a solution elegant. As this is, in part, what visual analysis seeks to achieve, these aspects of authentic learning benefit learning that uses visual analysis.

2.3.5 Context-aware learning

A learning context is defined as "the circumstances in which, or conditions that surrounds the learning" (Basaeed, Berri, Zemerly, & Benlamri, 2007, p. 5). Context-aware learning is the "system ability to dynamically change its characteristics to reflect changes in the learning context" (Basaeed et al., 2007, p. 5). Context-aware learning is most often enabled by mobile devices such as smartphones, or more precisely, the sensors they house, such as digital compass, GPS (global positioning system), temperature, humidity, altitude, biometrics, and cameras. It is no surprise then, that context-aware learning accounts for the inclusion of technological devices in m-learning definitions as offered by Sharples, et al. (2007) and Crompton (2013). The combination of these sensors with networked information providing additional information about the learner's environment could be used to support novice visual literacy learners to gain visual literacy from contingent encounters with visuals.

Context is important for the decoding of visual language. Gombrich (1972, 1977) believed that context, i.e. the circumstances or environment for a visual message, influences our reading of visual communications. Barnes (2011) explained how visual meaning making is influenced through her following example: a picture of a UFO on the cover of the *New York Times* will be interpreted differently than if the same picture was to occur on the front of a supermarket tabloid such as the *National Enquirer*. This difference in understanding of the image occurs as we have differing attitudes about the reliability of these sources. As context plays a role in decoding, it therefore stands to reason that learning systems that consider a visual's context would aid in a learner's decoding and subsequent analysis of the visual.

An example of context-aware m-learning capabilities can be seen in the Google Field Trip app, which takes advantage of cellular, Wi-Fi, and GPS functionality of a smartphone. The app runs in the background of a smartphone, and when a user gets close to a point of interest it directs their attention to its location and provides knowledge about the location on your device (Google, 2016). The experience can be likened to having a persistent travel guide; always there to point landmarks out to you and provide information about them as you go about your day. This application shows the potential of context-aware learning in visual literacy as it can use the smartphones sensors to both highlight and direct one to sense and select specific visuals in their surrounding environment while also imparting knowledge.

Another app, Yik Yak (discontinued in 2017), was a social network that connected users in physical proximity through discussion threads which were anchored in physical locations. Essentially, it could be thought of as a geo-located version of Reddit (www.reddit.com), with posts only visible if a user was located within a five-mile radius of it. Users had the ability to participate by writing and responding to discussion threads and up-voting or down-voting threads. This showed how learners could potentially collaborate based on locational context.

This research is not the first to investigate context-aware learning that highlights, informs, and constructs knowledge based on a learner's environment. One notable project called Empedia was created by researchers to provide a framework where educators could provide situated learning based on context-aware locative media delivered via smartphones (Rieser & Clark, 2013). One Empedia project, called Codes of Disobedience, had students collaboratively build a documentary trail through Athens (Hybrid City, n.d.; Rieser & Clark, 2013). While an excellent example of what can be achieved technologically, the Empedia framework is rudimentary in that the triggers for locative media were based only on geo-located areas. Even though Codes of Disobedience was a collaboratively generated experience, the collaboration was only between members of one isolated class, who published the documentary trail. Once published, users viewing the documentary trail have no way to contribute to it under the Empedia framework, making their learning experience a passive one.

2.3.6 Personalised learning

Atkins et al. (2010) describe personalised learning as the ability to tailor learning to account for three factors: pace, preferences, and specific interests. These three learning factors are also echoed by the former Minister of State and School Standards for the UK, David Miliband (2006), and again by Traxler (2011a).

A system that can account for pace, preference, and specific interests may have advantages over a one-size-fits-all approach to visual learning. Firstly, visual literacy is understood differently through a range of disciplines (Section 2.2). Personalised learning can account for this potentially disparate knowledge by tailoring it to a learner's discipline or needs. Secondly, allowing learner choice affords the opportunity for learners to pursue learning through their own culture (McCombs & Whisler, 1997). This would allow for one's cultural perspective to be accounted for in visual analysis, which is an important facet of analysis, according to Lester (2011) and improves the efficiency of learning (APA Work Group of the Board of Educational Affairs, 1997; Miliband, 2006). Thirdly, how much is learned, i.e. effectiveness, is directly associated with a learner's specific interests (Ghauth & Abdullah, 2010). As this research leverages contingent and situated learning, learners will be able to use their own interests as visual literacy learning opportunities and therefore the learning is expected to be more effective. Fourthly, a learner's intrinsic motivation to learn is also stimulated by providing personal choice and control (Fazey & Fazey, 2001; Ghauth & Abdullah, 2010). As this research implemented informal learning, there was no external motivator such as a teacher, and thus learners needed some form of intrinsic motivation to learn.

2.4 Challenges of M-Learning

This research implements m-learning as its practice-based component. To avoid known problems and to meet heuristic research's requirement to be thorough and gather the explications of others, this section will review m-learning's limitations. However, finding accurate and up-to-date publications that clearly outline m-learning's challenges, limitations, and weaknesses is problematic for two reasons. The first reason is directly linked to the fast changing nature of the field as a result of rapid advancements in mobile technology (Hashemi, Azizinezhad, Najafi, & Nesari, 2011). For example, Shudong and Higgins (2006) identified mobile phones camera's resolution as a key limitation. At the time, the highest resolution was Q-VGA 240 x 320 pixels. Ten years later, many mobile phones, such as Apple's iPhone7, have 12MP 3000 x 4000 pixel cameras as well as the ability to film 4K video.

The second reason why it is difficult to find a reliable overview of limitations is due to the tendency of the field to report only positive results. In a meta-analysis of 164 m-learning studies, Wu et al. (2012) showed that 142 reported positive outcomes while only one reported negative outcomes. The perception that positive results are more likely to be published is speculated to be one of the contributing factors to biasing results, but this is difficult to prove (Edwards, 2016; Fanelli, 2012). Fanelli (2012) claimed an analysis of over 4,600 articles from 1990 to 2007 which showed a steady trend of increasingly more positive results in research findings. Selwyn (2011) offered the explanation that educational technologists have a desire to make education a better place, which in turn sees an inherent positivity bias within educational technology scholarship. Further, this positive belief sees critical or negative analyses ignored or refuted as technophobia or naysaying, which has created a "with us or against us" dichotomy that limits critical perspectives on the use of educational technologies (Selwyn, 2011).

Despite the challenges in uncovering problems with m-learning, doing so is a necessary task for not only this research to proceed, but for the discipline as well. An understanding of potential challenges, weaknesses, concerns, and limitations may help this research avoid problems rather than proceed in blind faith, as Selwyn (2011) warned. To aid the process of uncovering problems, Shudong and Higgins (2006) offered a sound structure for discussion of m-learning's limitations, challenges, and weaknesses by classifying them under three categories: psychological, pedagogical, and technical.

2.4.1 Psychological limitations

M-learning is known for its anytime, anywhere access, but realistically how many learners are motivated enough to engage with learning after attending work or school? Shudong and Higgins (2006) believed that many learners lack the motivation needed to use a mobile phone consistently for learning. Cochrane (2013) emphasised this lack of motivation, stating the importance of sustained engagement as a critical factor in m-learning's success. Cochrane (2013) suggested one means of overcoming this may be to provide personalised learning, as it leverages intrinsic motivation.

Another argument is the problem of information and interaction overload. M-learning's anytime, anywhere access means there is potential that learners feel burdened to always be attentive. This may become overwhelming and lead to the learning experience becoming chaotic (Motiwalla, 2007). This is overcome in this research through the application of personalised learning, using a learner's personal preferences to limit learning opportunities. Additionally, students have blurred lines between their personal identity (the concept one has of one's self) and their device (Gikas & Grant, 2013). This is not surprising given the time spent on devices, and how social media apps are used by individuals to define and present themselves. M-learning can therefore intrude on a learner's personal space, resulting in learners disconnecting from m-learning entirely as a means of escaping the pressures of always being encouraged to learn.

Not everyone perceives m-learning and the use of technology or social media to be beneficial. A study from Gikas and Grant (2013) showed that some Millennials felt the use of mobile devices in learning could potentially be distracting. As these devices also have social media accounts attached, there are ever-present distractions when learning that threaten to lure learners' concentration away. At the heart of the problem is that the widespread adoption of mobile devices did not occur for m-learning's sake, but rather as a platform for communication and entertainment. New Zealand marketing statistics for 2014 showed that mobile device usage was 122 minutes (Statista, 2014a) and social media usage at 126 minutes (We Are Social, 2014), per person, per day. M-learning must compete for time on an already busy platform.

Learners need time (Shudong & Higgins, 2006) and support (Cochrane, 2012) to adapt to m-learning. While Millennials use mobile devices frequently, and have some understanding of their use for their own purposes, they still need time and support if there is to be a shift towards becoming students of anytime, anywhere learning (Cochrane, 2012). It is essential therefore to have a supportive learning community as well as technological and pedagogical support available (Cochrane, 2012). Providing support was the prompt that led this research to explore m-learning as a means of supporting visual literacy learners so they may learn from their environments. Therefore, this research considers support on two levels; addressing how to foster a community that may support itself, and how to provide external support.

Another problem with the use of the technology associated with m-learning is the perception that the technology may be harmful. This concern can be seen in a study that polled opinions on phone use and found that 60% of the participants agreed that the use of mobile phones by children and teenagers should be restricted due to possible health risks (Siegrist, Earle, Gutscher, & Keller, 2005). The perception of possible health risks can be seen in press releases by the World Health Organisation who believed radio-frequency electromagnetic fields, such as those emitted by mobile phones, are possibly carcinogenic to humans (World Health Organisation, 2014). This has cast doubts on how safe mobile devices are for use. It is therefore an important ethical consideration that any learning that utilises smartphones is optional, out of respect to those who perceive risk and do not want to be involved.

2.4.2 Pedagogical and epistemological limitations

Progress tracking and assessment can be a challenge with m-learning. Shudong and Higgins (2006) stated that as learning can take place anytime and anywhere, it can be hard to follow-up as individuals' learning achievements become scattered across time and space. Also problematic is the issue of trust. As Shudong and Higgins (2006) point out, m-learning assessment can take place anywhere, so there is no way to be certain of the authenticity of an answer. Thus, some m-learning assessments may be easily cheated, as less scrupulous persons could have a more capable individual complete the assessment on their behalf, or have reference material or notes available while sitting the assessment. Also worth noting, Cochrane (2012) mentioned instances of m-learning that failed as a result of educators not being able to integrate assessment into m-learning, stating the ontological shift required is difficult for some educators to come to terms with. This research bypasses any problems with formal assessment, as it aims to be informal learning.

Distance learning, e-learning, and Massive Open Online Courses (MOOCs) have been known to have high non-completion rates (Jordan, 2015a; Martinez, 2003). Given that m-learning is a specialised type of distance and e-learning, it is worth noting this as a caution. MOOCs have low completion rates, with an analysis of publicly available information showing an average completion rate of 15% (Jordan, 2015b). Rovai (2002) stated that distance education courses have 10-20% higher dropout rates than their traditional counterparts. He argued this could be due to students often enrolling in distance education to obtain knowledge, not credit. But more importantly, Rovai (2002) cited a lack of community and isolation for those undertaking distance learning as one of the biggest reasons for non-completion. Rovai's (2002) view supports the argument for community support and fostering a sense of community in learning visual literacy through m-learning.

The availability of technology in learning has created a breadth of choice for learners. Online learning has exploded to offer a vast array of materials. Statistics from Google reported that 67% of Millennials, those reaching young adulthood in the early 21st century (Oxford Dictionaries, 2015), believed they can find a YouTube video for anything they want to learn, and that 91% of all mobile users will turn to their devices to seek learning in what Google referred to as 'I want to do' moments (Mogensen, 2015). This demand has seen a large amount of online learning material created, which poses a problem. With such large amounts of content available, how does a learner navigate and find the learning they need? Ghauth and Abdullah (2010) argued that learners now spend more time browsing and filtering information that suits their needs, rather than undertaking actual learning.

When using mobile technologies for education there is always the possibility that the environment and surroundings can interrupt the learning process. Some examples of interruptions may be glare from the sun making a mobile screen hard to see, a sudden influx of noise in the environment breaking one's concentration, or cellular and Wi-Fi connection dead spots breaking access to learning materials (Dennen & Hao, 2014). Parsons, Ryu, and Cranshaw (2006) acknowledged similar problems, and advised that user interfaces for m-learning should deliver small self-contained modules of information and avoid adding any superfluous information to help combat usability issues.

2.4.3 Technical limitations

The development of mobile technology has been fast since the turn of the millennium. Late 2000 saw the introduction of the first mobile phones with cameras, boasting a measly 0.11 megapixels, while just over ten years later the Nokia Lumia 1020 had 41megapixels (Hill, 2013), or roughly 370 times more resolution. Smartphone ownership rates were at 70% for New Zealand in 2015 (Research New Zealand, 2015) and will hit an estimated 90% by 2018 (Frost & Sullivan, 2016). This rapid development makes stating specific limiting factors with mobile technology difficult, as many past studies, even if only a few years old, contain outdated or irrelevant information. It also means any limitations identified in preceding sections of this chapter and any limitations observed in this research may potentially be overcome or become irrelevant in the next few years. The rapid development of mobile technology, or more precisely, the risk of sudden obsolescence, can be a challenge (Crescente & Lee, 2011). The biggest problem caused by this rapid advancement, however, is device redundancy. Devices become redundant quickly (Hashemi et al., 2011), which makes developing a model for longevity difficult. For example, new technologies, such as mobile heads-up displays (HUDs) and other wearable computing recently released (such as Microsoft HoloLens) and withdrawn (such as Google Glass), make predicting what will happen in the next few years difficult, and could potentially render this study redundant before it is even released.

At present, input for mobile devices is rather cumbersome. Shudong and Higgins (2006) pointed out that user input speeds for text on smartphones is less than a tenth of the input speed when compared to using a computer keyboard. While one can attach keyboards to mobile devices, both transporting and using a keyboard makes a mobile device less mobile. Input via voice has been explored on many devices, but is still lacking even on the most cutting edge devices (Jacobs, 2013). Even if voice recognition were to become flawless, it is inappropriate in many public situations to speak aloud for input. This limitation extends to mobile heads-up displays, in which input is even more cumbersome than smartphones.

A technological challenge for m-learning is the physical size limitations of mobile screens, due to mobile phones' requirement to be portable. Crescente and Lee (2011) noted this, stating that material for smartphones needs to be purpose-built to the limitations of the device intended for consumption. Consequently, producing material that can suitably cater to a range of devices can be expensive. In the future, screen limitations may be overcome by HUDs, such as Microsoft HoloLens, which can take advantage of augmented reality to surround its wearer in a number of 720p HD screens (Hachman, 2016). However, for now, mobile devices are limited to physically small screens. This means content must be prioritised over interface elements, as the content is the primary reason for use of an app (Nielsen & Budiu, 2013).

Another key issue to be considered when developing an app for m-learning, is that both the hardware and software used for m-learning suffers from a lack of standardisation, which can make catering to learners devices difficult (Crescente & Lee, 2011; Shudong & Higgins, 2006). For example, Samsung alone had 26 screen variations in its 2012 mobile line-up (Segan, 2012). This problem only becomes worse when exploring the current mobile market, saturated with smart device manufacturers and operating systems.

2.5 Learning Models

In Chapter 1, it was noted that a common criticism against m-learning was a perceived lack of pedagogical consideration (Section 1.5). Therefore, it was deemed necessary to review pedagogical models so that they may inform the outcomes of this research. A simple explanation of a learning model or pedagogical model is that it is a collection of assumptions (commonly referred to as pedagogical assumptions) about how people learn (Leidner & Jarvenpaa, 1995). Three pedagogical models were selected for review based on their usefulness to this research. The first was the constructivist learning model, as its pedagogical assumptions of assimilation and adaption have already been noted as important to this research (Section 1.4). Supporting novice visual literacy learners is noted as important earlier in this thesis (Sections 1.3, 2.3.3, and 2.4.1), so collaborative learning is then reviewed as a means of providing support. This is followed by rhizomatic learning as it provides some means for learners to organise themselves. This is required as this learning will occur as informal learning, and therefore have no formalised role to set content or organise collaboration (Section 2.3.1).

2.5.1 Constructivist learning model

The primary assumption of the constructivist learning model is that knowledge is constructed or created within a learner's mind (Leidner & Jarvenpaa, 1995). The initial ideas for constructivism can be found in seminal books such as Dewey's (1910) *How We Think*, Paiget's (1936) O*rigins of Intelligence in the Child*, and Vygotsky's (1978) *Mind in Society*. These authors postulate that learners do not just absorb knowledge, but actively construct information by trying to organise and make meaning of it. The constructivist learning model stems from its epistemological stance being rooted in constructivism, i.e., that knowledge is subjective, and as such the mind does not replicate an external reality, but rather constructs its own (Springer, 2012; Yager, 1991). According to constructivists, it is one's experiences that shape or refine one's schemata (mental constructs or knowledge) and are how we come to understand the world (Bruner, 1986). As prior experiences are responsible for understanding new experiences, they play an important role in the learning process (Vygotsky, 1978). Constructivists therefore place particular importance on individual knowledge, beliefs, and skills (Springer, 2012).

Of particular interest to this research is cognitive constructivism, as its importance was noted briefly in Chapter 1 (Section 1.4). Specifically, Chapter 1 presented the cognitive constructivist concepts of *assimilation* and *accommodation,* as they speak to why visual literacy learning requires learners to have prior knowledge (memories, schemata, and mental models). Memory is arguably one of the most important mental activities involved in how we perceive; it ties what we are seeing to everything we have seen, and therefore influences our perception (Lester, 2011). The importance of memory when perceiving is noted by Huxley (1943), Bloomer (1990), Jamieson (2007), Lester (2011), and Helmholtz (1925). Huxley (1943) stated that to perceive we require "a store of accumulated experiences and a memory capable of retaining such a store" (p.11) and "heightened powers of perception tend to improve the individual's capacity for sensing and seeing"(p. 13). This leads to a self-reinforcing loop, where perceiving increases our store of memories, and increasing our store of memories improves our ability to perceive (Lester, 2011), much the same as assimilation and accommodation.

Through assimilation and accommodation, Piaget (1973, p. 20) believed discovery is the basis of learning, stating, “To understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition”. It can therefore be said that constructivist learning encourages learners to uncover knowledge for themselves, rather than be told or instructed. Learning outcomes are a result of what knowledge is encountered and subsequently processed by learners (Yager, 1991).

Constructivism as a learning model has two root variations; cognitive constructivism and social constructivism. Piaget (1971) first published on cognitive constructivism, which was later followed by Vygotsky’s (1978) work on social constructivism. Vygotsky (1978) mostly agreed with Piaget (1971), but placed more weight on the social aspect of constructivist learning. Vygotsky (1978) postulated that a subjective view of reality is formed through social interactions. Vygotsky therefore emphasised the cultural and social context for cognitive development (Springer, 2012; Vygotsky, 1978).

At the core of social constructivism is the zone of proximal development (ZPD), introduced in the first chapter of this thesis. Vygotsky (1978) described the ZPD as the difference between what a learner can achieve or answer on their own, compared to if they had guidance or operated in collaboration with more capable peers. The role of learning providers is to deliver learning that falls within an individual’s ZPD, thereby encouraging and advancing an individual’s learning through the example of their more capable peers (Vygotsky, 1978). The aim is to stretch a learner beyond what they can achieve on their own, but not beyond their abilities when receiving some form of assistance from peers. Wass and Golding (2014) elaborated on the ZPD, providing clarification about how this might happen within a traditional classroom setting. They stated that further to providing tasks within a learner’s ZPD, teachers should provide just enough scaffolding to aid a learner so they can learn to solve problems independently. Although Wass and Golding (2014) intended this for a classroom environment, the ideas have the potential to be translated into informal learning contexts by substituting the role of teacher with peers, systems, and community; such as can be seen in Dillenbourg's (1999) recommendations for collaborative learning, as discussed in the next section.

2.5.2 Collaborative learning

Collaborative learning can be thought of as a specific implementation of constructivist learning (Leidner & Jarvenpaa, 1995), and is often associated with social constructivism (Cheong et al., 2012). The primary difference between collaborative learning and Piaget's (1973) theory of constructivism is that community and socialisation have a role in knowledge construction. In Chapter 1 the circular reference problem highlighted the challenges visual literacy learners face when separated from their learning support (Section 1.4 and Figure 1-3). Through the literature reviewed, informal learning was identified as appropriate to address this problem. However, one question is yet unanswered: where does the support (imparting knowledge and highlighting visuals) come from? As noted in Section 2.3.1, informal learning would have no appointed teacher in a formal sense, so who would impart knowledge or highlight visuals to begin the learning process? In other words, who would provide the scaffolding or peer support required by Vygotsky's (1978) ZPD? One potential answer to the problem could be other learners in a community setting.

Generally, collaborative learning is an umbrella term that covers a range of approaches in which learners achieve some academic goal together (Cheong, Bruno, & Cheong, 2012) and use social interaction as a means of constructing knowledge (McInnerney & Roberts, 2004). Learners are placed into pairs, groups, or communities where they collaborate to form questions, discuss ideas, explore solutions, complete tasks, and reflect on their thinking and experiences (Hsu & Ching, 2013). This situates learners in learner-centred activities that allow them to take charge of their own learning, generate shared meanings, and develop critical and reflective thinking skills (Cheong et al., 2012; Hsu & Ching, 2013).

The self-directed, critical, and reflective skills that collaborative learning upholds, according to Cheong et al. (2012) and Hsu and Ching (2013), are of use to this research. Specifically, the self-directed aspect is needed, as this research intends an informal learning approach. As informal learning has no extrinsic motivators in the form of teachers or formalised assessment (Drotner, 2008), the learning approach adopted by this research requires learners to take charge of their own learning to form a community to provide support. The critical and reflective skills are also of importance as they are key factors in visual analysis (Section 1.3), and therefore would be part of the learning objectives for any learning that utilises visual analysis.

For learners to engage with a collaborative learning community there are several key points of consideration that must be met, according to Cheong et al. (2012). A space for interaction must be provided if collaboration is to occur. The space provides a shared social context for learners to socialise, learn, and construct knowledge. The shared context can be provided via artefacts (some object) within the shared space, which facilitate a common ground between learners to begin socially constructing knowledge. Cheong et al. (2012) also stated that a framework for communication needs to be established to elicit responses and allow learners to find different perspectives. This communication framework should make learners aware of social factors, such as if other learners are around, any actions other learners have performed, and how they are progressing.

Within this research which utilises m-learning, it is safe to assume that the learning community will be digital in some way to provide the required space for interaction and knowledge construction to occur. However, this current research aims to use the visuals in a learner's environment as a learning resource. Here, environment refers to the surroundings or conditions in which a person lives or operates (Oxford Dictionaries, 2017b). It must therefore be assumed that physical locations and their conditions will also be a part of this community space. As this research is focused on visual analysis, the artefacts referred to by Cheong et al. (2012) used to generate a common context for learners to begin socially constructing knowledge, will be visuals, or more accurately, anything that one can see to highlight or select. For socialisation to occur between learners, these visual artefacts will need to have some permanence in the digital and physical manifestation of the learning community to allow time for interactions to take place, especially if communication is asynchronous. These requirements therefore limit the type of visuals that could be used. For example, a television ad has no temporal permanence and so would not be appropriate.

Another key to collaborative learning is the interaction itself. Dillenbourg (1999) stated that curriculum designers should scaffold interactions by encompassing rules around them in the medium. As social constructivists believe social interactions are essential in knowledge construction (McInnerney & Roberts, 2004), it stands to reason that some thought must be given to how to encourage interactions that are positive to learning. Dillenbourg (1999) believed that in digital settings one means was to design an interface that sets rules that promote interactions germane to learning. Interface elements may illicit a predefined response, such as Facebook's "like" button, or an open-ended response such as Facebook's "tell us what is on your mind" dialog box. Interface elements such as these can act as scaffolds that are designed to minimise off-task interactions, which may otherwise derail or distract learners from the learning objectives.

Dillenbourg (1999) argued that in addition to interface design, there is also a requirement to regulate interactions in digital communities that utilise social interactions as a means of knowledge construction. Dillenbourg (1999) stated in formal learning, that this role is appointed to a facilitator, who is not to provide or highlight the right answers, but to perform minimal pedagogical intervention, or simply monitor if members are marginalised. This presents an interesting problem in this research: being informal, there is no formalised teacher or facilitator role. Instead the learning community will need to regulate itself somehow. This is not a new concept, informal learning sites such as Stack Overflow (www.stackoverflow.com) provides online communities with tools to moderate themselves. Stack Overflow is a collaboratively edited question and answer site for programmers (Stack Overflow, 2015). Essentially, a community of professionals come together to exchange knowledge, prompted by specific user questions. The self-regulation takes place through a system of "up-voting" responses to specific questions so they appear higher in a list of all answers given to that specific question, with additional facility to comment on the answers. The commenting and up-voting serves to regulate knowledge as the community decides the best answers, and modifies or expands on these answers through the commenting system. Similar mechanics can be seen in Reddit, a news up-voting site where content is aggregated through users up-voting and commenting on it (Reddit, 2015). Systems such as these, purposed for learning, can be explained as a form of rhizomatic learning.

2.5.3 Rhizomatic learning

Rhizomatic learning can be considered to be a decentralised or distributed twist on social constructivist pedagogies. The learning theory takes both its name and core principles from rhizomatic plants, which have no centre or defined boundaries but are made up of semi-independent nodes, each of which is capable of growing and spreading on its own (Cormier, 2008). The learning model is an adaption of rhizomatic thinking, originally proposed by Deleuze and Guattari in 1987 (Mackness & Bell, 2015), in order to overcome education limitations in subjects that are new, evolving, and do not have an accepted canon of knowledge (Cormier, 2008). Visual literacy and visual communication both suffer from a lack of widely accepted definitions (Avgerinou & Ericson, 1997) and a lack of universally recognised or canonical texts (Griffin, 2008). Hence visual literacy learning may benefit from a rhizomatic approach.

In the rhizomatic learning model, the curriculum is not predefined by experts or teachers, instead, "community acts as the curriculum, spontaneously shaping, constructing, and reconstructing itself and the subject of its learning in the same way that the rhizome responds to changing environmental conditions" (Cormier, 2008, p. 5). This means the community goes beyond just an access point to the curriculum; members contributions are added to and reshaped by the community to construct knowledge collaboratively. The preceding section notes that other learners can provide support through collaborative learning. Rhizomatic learning explains how this collaborative support may work in an informal setting.

There are few clear descriptions of rhizomatic learning's tenets. There are, however, models of the mind as a rhizome, such as those provided by Cunningham and Duffy (1996). They suggested the tenets of the rhizome model are that, 1) every point can be connected, raising the possibility of an infinite juxtaposition, 2) focus is on connections or relationships rather than fixed points, 3) the structure is constantly changing and dynamic so that any point can be disconnected and reconnected, 4) there is no hierarchy or genealogy that places one point above or before another, and 5) the rhizome consists of an open network that can be connected with something else in all of its dimensions (Cunningham & Duffy, 1996). Rhizomatic learning, in a digital context, therefore seeks to establish a dynamic open digital network of learners with no hierarchy that focuses on connecting, disconnecting, and reconnecting learners with both knowledge and with each other.

2.6 Chapter Summary

This chapter has reviewed literature from visual literacy, m-learning, and pedagogical models to define and connect the subject matter that underpins this study. Visual literacy is defined by this research using Hortin's (1983) definition, which posits that visual literacy is the ability to understand and use images, and to think and learn visually. Scholarship relating to visual literacy is further reviewed using Avgerinou and Pettersson's (2011) proposed conceptual components of visual literacy, namely: visual perception, visual language, visual learning, visual thinking, and visual communication.

With visual literacy defined, literature relating to m-learning and pedagogical models was then reviewed, with focus given to how they apply to visual learning. This focus connected ideas from visual literacy to m-learning and pedagogical models to help understand how visuals we encounter everyday could be leveraged as opportunities for learning visual literacy. This knowledge lays the groundwork for the learning model proposed by this research in Chapter 4.

This chapter has also reviewed scholarship of m-learning's psychological, pedagogical, and technical limitations and challenges. These limitations establish boundaries for the practice-based component of this study, which aimed to create an m-learning app.

Chapter 3: Methodology & Research Design

3.1 Introduction

In Chapter 1, the research direction was introduced as an exploration of how the visuals one encounters every day can be leveraged as opportunities for learning visual literacy. The scholarship of Puentedura (2006b) and Hockly (2012) suggested that for this exploration to have the greatest chance of being both successful, and to provide some new contribution to knowledge, it must aim to offer learning activities that are purpose-built to fully leverage pedagogical and technological affordances (see Section 1.5). Therefore, it was critical for this research to set an approach that could explore the pedagogy and the technological affordances of m-learning for the learning of visual literacy. As no such approach currently exists, a practice-based approach was tailor-made by synthesising a heuristic inquiry and user-centred design into a systematic problem-setting and -solving research design based on this study's research aim and questions.

3.2 Philosophical Assumptions

As this research draws on knowledge from several fields and is likely to be read by people of diverse backgrounds, it seems appropriate to clarify the philosophical assumptions of this work. This may help avoid misinterpretations resulting from ontological or epistemological differences that a reader may bring.

This current research uses a qualitative interpretive framework based on pragmatism's philosophical assumptions. Creswell (2012, 2013) and Cherryholmes (1992) stated that individuals using a pragmatic worldview will use multiple methods and sources to obtain data, will focus on the practical implications, and will stress the importance of conducting research that best addresses the research problem. Solutions to problems are the key concerns. Feilzer (2010) wrote that pragmatism "aims to interrogate a particular question, theory, or phenomenon with the most appropriate research method" (p. 13). As the research questions for this research were developed from a desire to solve a real-world problem (i.e. supporting visual literacy learning in informal settings), pragmatism allowed for the focus of this research to remain such that the research questions may be solved.

Pragmatism, as outlined by Creswell (2012, 2013), Feilzer (2010) and Cherryholmes (1992), is characterised by unique features, which were of use to this research. First, pragmatism is not committed to any one ontological belief. "Reality", as viewed through the lens of pragmatism, is considered what is useful and practical to the research. This allowed this research to traverse several different domains of knowledge that needed to work together despite holding different views. To subscribe solely to an ontology of one domain may preclude knowledge from others, making this specific research impossible. Second, pragmatism allows for a range of epistemological assumptions and multiple methodologies to be used together (Creswell, 2012, 2013). This is important as it allowed heuristic inquiry and user-centred design to be synthesised into a unified approach with a focus on solving the research questions.

3.3 Practice-Based Research

Practice-based research describes an original investigation undertaken in order to uncover new knowledge, "partly by means of practice and the outcomes of that practice" (Candy, 2006, p. 1). A key feature is a requirement to create some artefact (Biggs, 2003). An artefact in practice-based research refers to a human made object or outcome, for example, a painting, music, digital media, or performance (Candy, 2006). In this research, the artefact is a prototype for a smartphone application (app).

Practice-based research should not be confused with practice-led research. As some researchers mix the terms freely, this paragraph will briefly clarify the difference to avoid any confusion in this research. The main concern of practice-led research is the nature of a practice and the operational significance for that practice. Candy (2006) clarifies the difference of these two approaches based on their outcomes. If an artefact produced is the basis for the knowledge, the research is practice-based. If the research leads to new knowledge about a particular practice, then it is practice-led. As a prototype for a smartphone app (i.e., an artefact) will partly represent this thesis's contribution to knowledge, this research fits Candy's (2006) description of practice-based research.

Practice-based research suffers from a lack of standardised approaches. Scrivener (2000) stated that there is generally no agreed upon methodology, commenting that, "the problem finding and solving processes retain an element of the black arts" (p. 5). Walters and Morgan (2011) state this problem is the result of design being rooted in the everyday, therefore practice-based research has a large pool of methodologies, methods, and concepts to draw upon. This has resulted in practice-based research not developing a consistent specific design ideology. For this research then, a tailor-made approach was implemented based on heuristic inquiry, and user-centred design.

3.4 Heuristic Inquiry

Heuristic inquiry is a practice-based research approach that draws on the personal experiences and insights of the researcher. Heuristic inquiry sees the researcher probe some phenomenon, in this case the learning of visual literacy, by reflecting on their personal experience of the phenomenon and the essential experience of others who have experienced the same phenomenon (M. Patton, 2002). Moustakas (1990, p. 9) described heuristics as "a process of internal search through which one discovers the nature and meaning of experience and develops methods and procedures for further investigation and analysis".

According to Sela-Smith (2002), the goal of heuristic inquiry is exploratory discovery rather than hypothesis testing, situating heuristics as a type of inductive logic. Thus, heuristic inquiry is useful when there is a lack of clarity regarding the final output, as was the case with this research's sequential approach. As the tenets of the learning model could not have been known at the outset, the final output of an app based on these could not have been known either. Heuristic inquiry allowed this research to be purposefully open-ended, using the research direction as a guide. The focus of heuristics on exploratory discovery leads to an approach that places emphasis on what works and allows for processes, techniques, and tools that makes sense to the researcher to be tested (Moustakas, 1990; Sela-Smith, 2002). Heuristic research offers the ability to venture into research areas that are less developed (Sela-Smith, 2002), such as with visual literacy in context of m-learning.

The open processes of heuristic inquiry can be thought of as a double-edged sword. While it allows flexibility to research in less developed fields, this comes at the cost of clear methods. In recognition of this potential weakness, this study supplemented heuristic inquiry with tailored methods from user-centred design with the aim of providing a clear and rigorous process. Heuristic inquiry became the overarching methodology supplemented by the processes and procedures of user-centred design.

A potential criticism of heuristic inquiry is that there are clearer methodologies sharing similar roots that are more commonly used, such as grounded theory, action research, or educational design research. Grounded theory is used to generate or discover a theory or model (Creswell, 2012), which is what heuristic inquiry has been utilised in this research for. However, grounded theory seeks to minimise the researcher's knowledge, as knowledge is viewed as objective and external rather than subjective and internal (West, 2001). Given the researcher's background and relationship to the research, grounded theory would limit this specific investigation as considerable energy would need to be invested in laying the groundwork to demonstrate, prove, or corroborate what is already known colloquially and tacitly through ten years of the researcher's personal experience. Additionally, heuristic inquiry allowed for a practical component following the explication of the learning model – i.e. explication to creative synthesis. This was important as a criticism of m-learning is that it often estimates what is achievable (Selwyn, 2011). Action and educational design research could have both addressed the practice-based component of this study as both share a similar cyclic, iterative approach to research that, in hindsight, may have worked. However, as this research was an explorative study, the outcomes could not be planned, and therefore committing to cycles of practice and reflection was deemed inappropriate as their involvement was an unknown at the outset. Again, this is a problem of tacit knowledge as Douglass and Moustakas (1985) explain, "knowing more than can be articulated shrouds discovery in mystery, lending intrigue to immersion in the theme or question" (p. 49). Heuristic inquiry therefore stood as a suitable candidate for this study as it allowed the researcher to approach what started off as a hunch, and tease it out into something with wider implications over time.

Heuristic inquiry has several phases and concepts. The phases guide researchers through a series of sequential procedures. The concepts are not tied to any specific phase and are used throughout the phases. The following sections outline these phases and concepts in detail.

3.4.1 Heuristic concepts

Heuristic research explicitly acknowledges the involvement of the researcher; indeed, the researcher is paramount to the process. The researcher's involvement in heuristic inquiry is achieved through a number of processes and concepts, namely, identifying with the focus of the research, tacit knowing, intuition, indwelling, focusing, self-dialogue, and working with and through an internal frame of reference. In this research, these processes and concepts played a significant role in the creation of an artefact and the data analysis.

The first core concept is *identifying with the focus* of the research. The researcher must have a significant interest in and experience of the research topic to meet this criteria (M. Patton, 2002). Identifying with the focus allows one to "get inside the question, become one with it, and thus achieve understanding of it" (Moustakas, 1990, p. 15). The researcher, as an academic and educational technologist, has spent considerable time engaged with educational technology and visual literacy education which helped him to identify this study's specific research problems.

Tacit knowledge is key to heuristic research. The term tacit knowing was first coined by Polanyi (1966) and can be summarised as "we can know more than we can tell" (Polanyi & Sen, 2009, p. 4). Tacit knowledge is often defined loosely, as it is hard to define by its very nature. For example, one definition is "skills, ideas and experiences that people have in their minds and are, therefore, difficult to access because it is often not codified and may not necessarily be easily expressed" (Chugh, 2015, p. 128), and another is "something not easily visible and expressible. … is highly personal and hard to formalize, making it difficult to communicate to others or share with others" (Nonaka, Takeuchi, & Umemoto, 1996, p. 834). Heuristic research regards tacit knowledge as the driving force behind intuition (Douglass & Moustakas, 1985). Tacit knowledge is also key in practice-based research, as "competent practitioners usually know more than they can say" (Schön, 1983, p. 8). However, Candy (2006) cautioned PhD students that one must be careful about considering tacit knowledge as a contribution to knowledge, as by its nature, it is not sharable or challengeable. Therefore, although this research draws and relies on tacit knowledge to aid in the formation of ideas, these ideas are then made explicit through the conceptualisation of the thesis and the development of practical outcomes.

Intuition connects or bridges tacit knowledge to explicit knowledge (Bach, 2002), and can therefore be thought of as one of the processes that permits tacit knowledge to be drawn on. Intuition is key to being original and discovering new ideas as it provides a means of seeing the world in new ways. Intuition allows knowledge to be arrived at without mediating steps, such as logic and reasoning, and can be used to infer something as a whole from only examining its parts (Douglass & Moustakas, 1985). Specific to research, intuition allows for shifts and alterations in methods, procedures, research direction, and understanding as needed to enrich the research based on where clues and hunches are leading the researcher.

Intuition in practice is what Schön (1983) refers to as *knowing-in-action* and *reflection in action*. Schön (1983) gives an example of a competent bicycle rider; if they start to fall to the left they know how to correct but would struggle to explain why or how and when this correction occurred.

> This capacity to do the right thing…. exhibiting the more that we know in what we do by the way in which we do it, is what we mean by knowing-in-action. And this capacity to respond to surprise through improvisation on the spot is what we mean by reflection-in-action. (Schön, 1983, p. 11).

Indwelling, as the name implies, is the internal process of dwelling to increase understanding (Bach, 2002). Moustakas (1990, p. 24) describes this as the "process of turning inward to seek a deeper, more extended comprehension of the nature or meaning of a quality or theme of human experience". Indwelling sees the researcher follow clues and then dwell on them to expand and elucidate understandings, meanings, and associations, with the goal of achieving fundamental insights. This is a conscious and deliberate process requiring patience in order to increase understanding incrementally (Moustakas, 1990). The research design of this study achieved this process by specifically stepping through methods and research questions in a manner that sees each build on knowledge uncovered from the last.

Focusing is much like indwelling, but with the intention of elucidating explicit themes when analysing data. By tapping into thoughts and feelings, the researcher can clarify and better understand a research question, explain its constituent parts, and identify and explicate its core themes (Sela-Smith, 2002). In this study, the result of focusing can be seen in the tentative learning model, with themes identified as pedagogical assumptions.

Self-dialogue is a unique feature of the heuristic inquiry process. This is where researchers attempt to dialogue with themselves in regard their and others' experiences (Kenny, 2012). This process allows self-knowledge to be unearthed (Bach, 2002). According to Moustakas (1990), knowledge is formed of direct human experience, and discovery involves self-inquiry of these experiences. Self-dialogue often occurs when taking notes, which can be revisited and added to, thereby creating a conversational record of the researcher's self-dialogue.

All the heuristic processes relate back to one's *internal frame of reference*. To understand human experience, one must consider others' experiences in relation to their own internal frame of reference (Moustakas, 1990). This creates a requirement to converse with people to understand their experiences and, if conducted with empathy, Moustakas (1990) claimed, can change one's own internal frame of reference and create new awareness.

3.4.2 Heuristic phases

The phases of heuristic inquiry provide methods as sequential steps for conducting research. According to Moustakas (1990), these phases are initial engagement, immersion, incubation, illumination, explication, creative synthesis, and validation (Figure 3-1). These phases come from Moustakas' 1990 guidelines, which have become the prevailing approach to heuristic inquiry, and consequently have a large a pool of knowledge to draw on. Moustakas is a leading authority in heuristic inquiry, as he not only originally proposed the methodology back in 1961 (Djuraskovic & Arthur, 2010), but stayed active in refining it until his death in 2012. Moustakas' (1990) heuristic guidelines have been used and demonstrated in previous technology-based research (Sela-Smith, 2002).

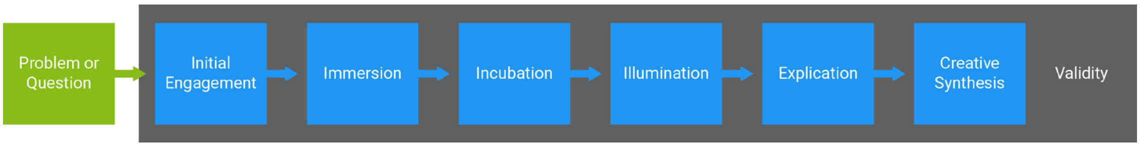


Figure 3-1: Author's visualisation of Moustakas' (1990) phases of heuristic inquiry.

The first phase of heuristic research is *initial engagement,* where one identifies a problem that is of personal importance from one's own experiences and tacit knowledge (Bach, 2002; Sela-Smith, 2002). One could therefore criticise heuristic research for yielding results that are only personally applicable. However, Moustakas (1990, p. 15) argued “with every question that matters personally there is also a social—and perhaps universal—significance”.

In the immersion phase, the researcher becomes fully involved or immersed in the research question. This requires the researcher to be alert to all the possibilities in their surroundings that can increase understanding of the research questions and anything that can be connected to the research becomes an opportunity for further reflection through heuristic core processes, particularly indwelling (Douglass & Moustakas, 1985).

Incubation is the third phase involving a retreat from immersion, intense focus, or pursuit of the research question (Douglass & Moustakas, 1985; West, 2001). This is to allow the inner workings of tacit knowledge and intuition a chance to develop and extend understanding beyond immediate awareness. Moustakas (1990) rationalised this phase through the anecdote of trying to actively remember a forgotten name, only to recall it later while engaged with another activity. Heuristic research tries to leverage this phenomenon by affording researchers time away from their research, so that they can discover knowledge that might not occur through deliberate mental action.

Illumination is the fourth phase. Illumination occurs at the moment that the internal workings of phase three, incubation, spontaneously breaks through into conscious awareness (Sela-Smith, 2002). Therefore, illumination cannot be planned. This phase is naturally occurring, taking place when the researcher is receptive to discovering what exists in their tacit knowledge and intuition (Bach, 2002). Illumination may create new awareness, modify an existing understanding, synthesise existing knowledge, or even discover something new.

Explication is the fifth phase, and is a process of elucidation. The purpose of explication is to examine all knowledge so far uncovered in order to conceptualise it (Bach, 2002). Focusing, indwelling, self-searching, and self-disclosure conducted through the researcher’s own internal frame of reference are used to re-organise and come to a more complete understanding of a phenomenon (Sela-Smith, 2002). This leads to a comprehensive depiction of core or dominant themes (Moustakas, 1990),

Creative synthesis is the sixth phase of heuristic research. It involves taking what has been explicated along with all the other knowledge uncovered and putting it into some creative output (West, 2001), such as an artefact, which is considered a contribution to knowledge (Candy, 2006). Moustakas (1990) did not stipulate what the creative synthesis should be. For this research, this phase consisted of implementing the tentative learning model by creating a prototype for an m-learning app. As heuristic inquiry has vague guidelines around conducting creative synthesis, this phase was supplemented with user-centred design.

Validation in heuristic research is not a phase that follows or is part of a linear progression, but instead is ever-present during all other phases. As heuristics draws on personal understanding and ends with some creative output, the validity of heuristic inquiry's outcomes cannot usually be determined by quantitative measurements or correlations (Moustakas, 1990). To compound this problem, validity in discovery research (such as this research) is not possible by comparing it to others' explorations. Instead, in heuristic research, validity is a question of meaning:

> Does the ultimate depiction of the experience from one's own rigorous, exhaustive self-searching and explications of others present comprehensively, vividly, and accurately the meanings and essences of the experience? (Moustakas, 1990, p. 32)

Asking the question above sees the researcher return to the phases again and again, breaking the linear process to constantly check, judge, and refine (Moustakas, 1990). However, it should be noted that heuristic inquiry is often regarded unsuitable for generalisation. This is due to heuristic inquiry drawing heavily on tacit knowledge to make intuitive leaps. This limitation was identified early in this research, so usability-testing, a user-centred design method, was added as an additional external validity phase to elicit others' responses as a part of the creative synthesis. This provided a means of further refining the results so that outcomes may be validated more broadly.

3.5 User-Centred Design

As noted in the proceeding section, Moustakas (1990) identified creative synthesis as a phase of heuristic research, but did not make it prescriptive. Therefore, the specific methods to conduct the creative synthesis phase of this research were taken from industry practice for app design and development; namely user-centred design (UCD). This is a specialised sub-domain of human-centred design specifically for software development.

UCD is defined as "the active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multi-disciplinary approach" (Vredenburg, Mao, Smith, & Carey, 2002, p. 472). UCD was proposed as an approach for overcoming traditional software design practices that focused too heavily on systems or technologies (Mao, Vredenburg, Smith, & Carey, 2005). As m-learning research has been noted to suffer similar issues of placing too much emphasis on technology (Selwyn, 2011), the application of UCD will aid in mitigating this issue. Additionally, as noted in the preceding section, heuristic inquiry may be criticised for producing results that are not generalisable. UCD includes methods for usability testing and interviewing which may help overcome issues of applicability and validity as they allow for outcomes to be tested, refined, and validated.

Usability testing, involves observing representative users attempting to perform representative tasks on prototypes or functional software in order to gather evidence on how usability may be improved (Lazar, Feng, & Hochheiser, 2017; Martin & Hanington, 2012). Usability testing is a common method in UCD on which practitioners place high importance and, as a consequence, has become a de facto standard for UCD practitioners (Dumas & Fox, 2009; Mao et al., 2005). UCD's close-knit relationship with usability testing is not surprising, as usability testing provides a means for the "active involvement of users for a clear understanding of user and task requirements" that is part of the definition of UCD offered by Vredenburg et al. (2002, p. 472).

Interviewing of users, potential or otherwise, is another common practice in UCD, used to probe the attitudes, beliefs, desires, and the experiences of users (Martin & Hanington, 2012). Interviews are versatile and flexible and can be combined with other methods of data collection (Kallio, Pietilä, Johnson, & Kangasniemi, 2016). The U.S. Department of Health and Human Services (2016a) recommended interviewing as it helps to better understand the people who will use your product, allowing software designers to devlop and refine products with the user in mind.

In addition to having methods to elicit feedback from users, UCD also includes methods for generating ideas and products. These methods are modular in nature, selected and arranged such that they may meet the designer's needs and budget (Mao et al., 2005); as such was the case with this research. In addition to the usability testing and interviewing employed by this research, the UCD methods utilised were: user-personas, scenarios, user story mapping, wireframes, and prototyping. These methods are explained in principle here, and in context to this specific study in the following section "Research Design."

Personas are a method used in UCD to represent the user in the design process. This allows for decisions to be made with the users in mind (Nunes, Silva, & Abrantes, 2010). A small set of personas are usually created in UCD undertakings that are representative of the main users and their primary reasons for using the software (Junior & Filgueiras, 2005; U.S. Department of Health and Human Services, 2016c). User personas can be created from various sources of information, namely consulting an expert, immersion, site visits, interviewing potential users, online surveys, focus groups, and collecting feedback from current users (IDEO.org, 2015; Junior & Filgueiras, 2005; Pruitt & Grudin, 2003; U.S. Department of Health and Human

Services, 2016b). There are no prescriptive guidelines for what a persona should be as they are often unique to the software in development, but they also often contain components that describe an individual through their goals, attitudes, quotes, and beliefs. Completed personas often take the form of posters or cards that can have some permanence in a designer's environment (i.e. a poster on the wall), so that when questions about features arise, the developer may refer to the persona and attempt an answer through the perspective of the personas (Pruitt & Grudin, 2003).

Scenarios are fictional accounts that explore the use of a product from a user's perspective (Martin & Hanington, 2012; U.S. Department of Health and Human Services, 2016d). They are essentially short stories ranging from a sentence to a couple of paragraphs that describe what people can do with a product, rather than how the product works. If personas have been created, they may use these representations of users as characters in the scenarios to add depth and consistency throughout the design. As they are written from the user's perspective, they help developers and designers think about the types of content, functionality, and behaviours users would like without focusing on technical considerations (U.S. Department of Health and Human Services, 2016d). Essentially, they provide context to products or services before they are created.

Once the scenarios are created, specific capabilities or features can be extracted from them by breaking them down into smaller components (J. Patton, 2014). This involves reviewing the scenarios, extracting all the tasks users can perform in the scenarios, and then mapping them out. This is known as a *user story map* and provides both the big picture and overarching goals of a product in development, and the details of what is needed to meet those goals through a collection of smaller user stories (J. Patton, 2014). The term 'user stories' can be misleading as it sounds similar to the scenarios explained in the proceeding section. A user story is essentially a short single sentence that explains some task a user wants to do with the product in development. These stories often follow the pattern "as a <user> I want to <feature> so that <value>" (Milicic, Perdikakis, El Kadiri, Kiritsis, & Ivanov, 2012, p. 62).

According to J. Patton (2014), a story map breaks functionality and features down into three levels of abstraction, using cards to arrange the user stories into a map. The top level of the user story map lacks detail and often describes an activity a user may wish to perform, or a screen from the software to be developed. The next level breaks the above level's activity or screen into steps or distinct functions to flesh out further detail. These top two tiers form the backbone or foundation of features the software will have. The third level breaks the second level down further to provide details on how the upper levels may be achieved, explicating the full feature set of the software under development.

Wireframes can be created using a story map, once the features of the software are conceptually understood. Wireframes are a common practice in UCD, consisting of low-fidelity mock-ups of screens of the software under development. Fidelity refers to the level of resolved finish of a design (Martin & Hanington, 2012). Low-fidelity mock-ups ignore aesthetics and detailed content. This is in recognition of a wireframe's purpose, namely, connecting the app's information architecture (IA, the structural design of an app's information) by showing how both screens and user interface (UI, the space where interactions between humans and computers occur) elements connect, developing a clear and consistent manner for displaying information, developing the functionality, and establishing the hierarchy of functions within screens (U.S. Department of Health and Human Services, 2016e). High-fidelity mock-ups are like wireframes, with the key exception that they also account for aesthetic considerations.

UCD also commonly employs prototyping, as once a prototype is created, it may be employed to elicit user feedback through usability testing. Prototyping is a process that sees the creation of some artefact that demonstrates the intent of a design concept before undertaking development (U.S. Department of Health and Human Services, 2016g). The purpose of prototyping is to make ideas tangible, allowing them to be shared, scrutinised, and tested by others (Martin & Hanington, 2012). Like mock-ups, prototypes can have varying levels of fidelity. Low-fidelity prototypes do not consider aesthetics and only include rudimentary interaction. The unfinished nature of low-fidelity prototypes is intended to provoke innovation and improvement, as potential users may feel more comfortable critiquing them and offering suggestions for improvement (U.S. Department of Health and Human Services, 2016g). High-fidelity prototypes attempt true representations of the user interface intended for development, which makes them a good choice for demonstrating what a final product may look like (U.S. Department of Health and Human Services, 2016g).

3.6 Research Design

The research design includes planning around two key outcomes. The first outcome is a learning model for visual literacy. The second outcome is a prototype smartphone app based on the learning model. This decision to focus on pedagogy first addresses Selwyn's (2011) critique, that educational technologists have, in the past, focused too heavily on technology to the detriment of their research. The prototype follows as a means of exploring technological affordances on which Puentedura (2006) and Hockly (2012) placed emphasis. The sequential arrangement of the two outcomes also adheres to heuristic inquiry's requirement to incrementally increase knowledge (Moustakas, 1990). This created a transition from inductive to deductive logic throughout the research, allowing the ideas generated to be implemented, tested, and potentially validated and refined.

Due to the heuristic inquiry requirement to incrementally increase knowledge (Moustakas, 1990), and the UCD requirement to design iteratively (Vredenburg et al, 2002), this research establishes three stages to address these requirements. Stage one conceptualises a tentative learning model. Stage two produces a low fidelity prototype. Stage three tests the tentative learning model and low-fidelity prototype to refine each based on the test's results.

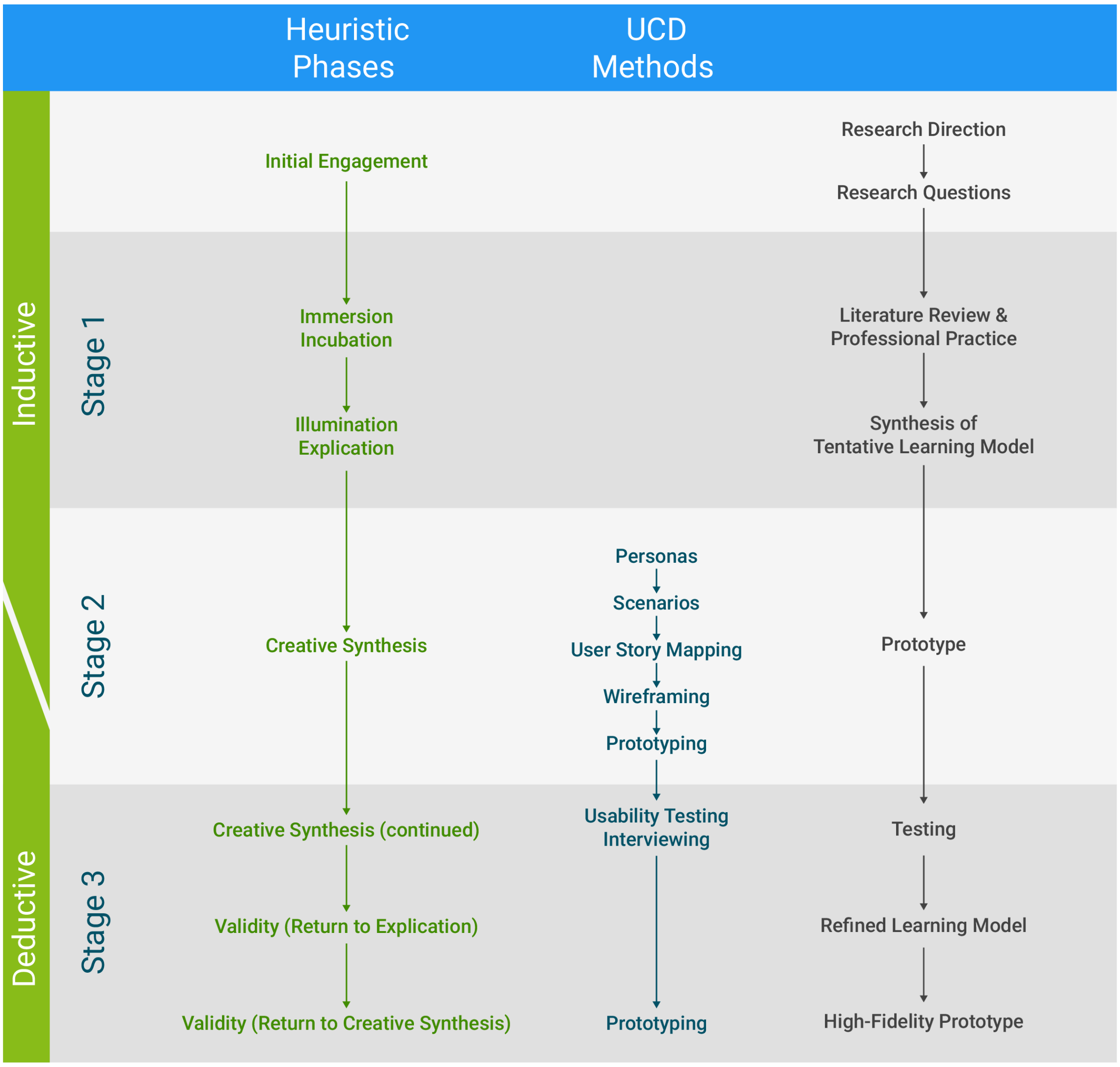


Figure 3-2: A diagram outlining the logic, heuristic phases, and methods of this research. Author's original composition.

Before the first stage of the research could be undertaken, the first phase of heuristic inquiry, the initial engagement must be met. This is used to set the research direction and subsequent research questions. This study's research direction (Section 1.6) developed from the researcher's experiential knowledge as a student who majored in visual communication, as an academic designing and delivering visual communication education, as a design professional, and as an educational technologist. The researcher believed that there were many unexplored opportunities for visual literacy learning, especially when paired with m-learning's notion of context-aware, anytime, and anywhere learning. From this general and broad research direction, specific research questions were developed (Section 1.6) using heuristic's core processes of tacit knowledge, self-dialogue, and, most importantly, identifying with the focus.

3.6.1 Stage 1: Learning model

The first stage of the research design aims to synthesise a tentative learning model specifically for visual literacy in an m-learning context. This synthesis is driven by RQ1: *How can everyday encounters with visuals be leveraged as visual literacy learning opportunities by providing learning support?* The synthesis of the learning model is achieved through inductive reasoning, which is used to generate the learning model's pedagogical assumptions. Inductive reasoning is typically achieved by an approach that moves through a process of gathering information, asking open ended questions, forming themes or categories, identifying broad patterns or generalisations, and finally posing a theory or theories (Thomas, 2006). To achieve this, the four phases following initial engagement of heuristic inquiry are employed. These are immersion, incubation, illumination, and explication.

Immersion occurs two ways in this research. Firstly, Vogt (2014, p. 142) stated that ideas are not formed in a vacuum, rather "theories are based on research, and that research is usually one form or another of literature review". Thus, immersion is conducted by employing a review of relevant literature. Secondly, the researcher's practice as a visual communication lecturer is maintained to allow for immersion in a daily environment germane to visual literacy and its learning. Oscillating between the two means of meeting heuristic inquiry's immersion phase allows for the incubation phase to occur simultaneously. As the researcher oscillates between the two different immersion activities, whichever is not the focus of the researcher's immediate attention is incubated.

As immersion and incubation are undertaken, ideas illuminated in literature, or experiences or ideas illuminated through practice that are relevant to the research focus, are explicated as written statements. As illumination is the impetus for explication, these occur as one process; as ideas are illuminated, they are explicated. Explicated statements are limited to assumptions on how learning may occur, operate, or be supported so that they may be synthesised into pedagogical assumptions.

Explication is then further employed to generate a series of codes from the explicated statements. The codes reduce the explicated statements into their constituent elements or essence. The codes are then grouped to form the initial draft of the pedagogical assumptions. Decisions on groupings are made using heuristic's core processes, especially indwelling and focusing, which are guided by the researcher's intuition.

The pedagogical assumptions are then reviewed and refined through further indwelling and focusing. The pedagogical assumptions have only been considered in isolation up until this point, so the review checks that the pedagogical assumptions do not overlap or contradict each other. The outcome of reviewing and refining is a cohesive, although tentative, learning model that describes how the visuals novice learners encounter everyday can be leveraged as opportunities to learn visual decoding skills.

3.6.2 Stage 2: Prototyping

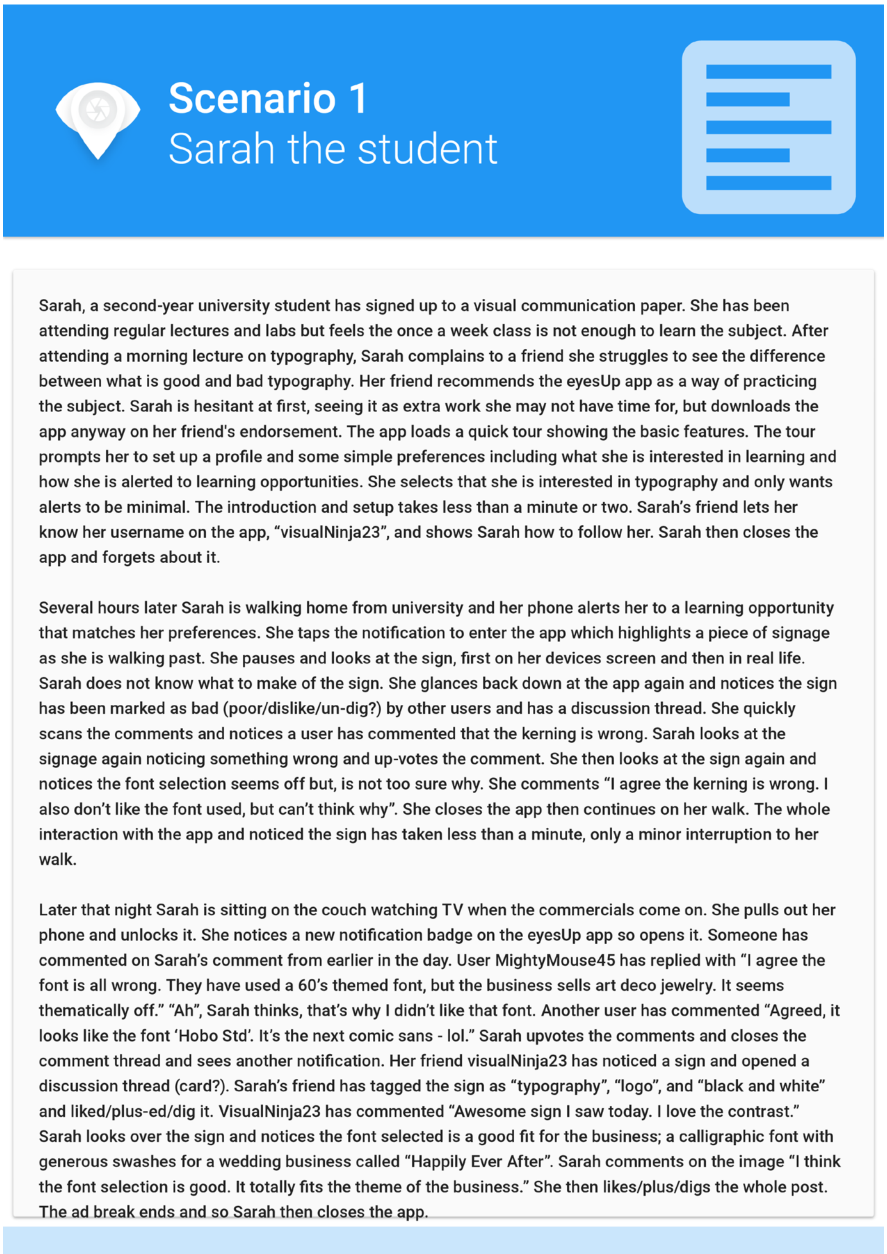
Stage two represents heuristic inquiry's "creative synthesis" phase, which, in this study, employs UCD methods. Stage two is directed at this study's second research question: *How can the learning model be implemented as a smartphone app?* This stage aims to create a low-fidelity prototype for a visual literacy m-learning application, which is designed based on the pedagogical assumptions of the tentative learning model produced in stage one of this research.

To begin the prototyping process, personas are created. Because this research seeks to create a new m-learning app, there are no existing users to gather data from. This limits the options for data sources to consulting an expert or collecting data from potential users. In this study, the researcher assumes the role of expert to create the personas. The option for collecting data from potential users was considered, however, the research was conceived from the researcher's empathetic understanding of the potential users through their professional practice and heuristic inquiry's initial engagement phase and process of identifying with the focus. Also, collecting data from potential users is a task in understanding their attitudes, beliefs, desires, and experiences to help set the goals of the app (Junior & Filgueiras, 2005; U.S. Department of Health and Human Services, 2016a). In the case of this research however, the goals are provided by the tentative learning model. It should be noted that while potential users were not consulted for creating the personas, users (actual or potential) cannot be excluded from the UCD process. Therefore, potential users are consulted in stage three of the research.

Three user personas are created. The first persona is representative of who the core user of this product will most likely be, namely learners (see Figure 3-3). The second persona is representative of educators who wish to introduce their students to tools that aid their learning. The third persona is representative of a visual practitioner who may be looking for a tool to stay current with visual trends, practice critical skills, or collect visual research.

Figure 3-3: An example of one of the user personas created. Author's original composition.

Scenarios based on the personas are then created (see Figure 3-4). The scenarios are used to begin translating the abstract ideas of the tentative learning model into something tangible by imagining how the pedagogical assumptions may be experienced by a user. This is an exercise in ideation that utilises heuristic processes of intuition, focusing, and self-dialogue. The scenarios are devoid of any technological considerations, as recommended by Martin and Hanington (2012), so that focus may remain on a user's experience. Each scenario created is a couple of paragraphs, so that they may account for all the facets of the tentative learning model.



Scenario 1
Sarah the student

Sarah, a second-year university student has signed up to a visual communication paper. She has been attending regular lectures and labs but feels the once a week class is not enough to learn the subject. After attending a morning lecture on typography, Sarah complains to a friend she struggles to see the difference between what is good and bad typography. Her friend recommends the eyesUp app as a way of practicing the subject. Sarah is hesitant at first, seeing it as extra work she may not have time for, but downloads the app anyway on her friend's endorsement. The app loads a quick tour showing the basic features. The tour prompts her to set up a profile and some simple preferences including what she is interested in learning and how she is alerted to learning opportunities. She selects that she is interested in typography and only wants alerts to be minimal. The introduction and setup takes less than a minute or two. Sarah's friend lets her know her username on the app, “visualNinja23”, and shows Sarah how to follow her. Sarah then closes the app and forgets about it.

Several hours later Sarah is walking home from university and her phone alerts her to a learning opportunity that matches her preferences. She taps the notification to enter the app which highlights a piece of signage as she is walking past. She pauses and looks at the sign, first on her devices screen and then in real life. Sarah does not know what to make of the sign. She glances back down at the app again and notices the sign has been marked as bad (poor/dislike/un-dig?) by other users and has a discussion thread. She quickly scans the comments and notices a user has commented that the kerning is wrong. Sarah looks at the signage again noticing something wrong and up-votes the comment. She then looks at the sign again and notices the font selection seems off but, is not too sure why. She comments “I agree the kerning is wrong. I also don't like the font used, but can't think why”. She closes the app then continues on her walk. The whole interaction with the app and noticed the sign has taken less than a minute, only a minor interruption to her walk.

Later that night Sarah is sitting on the couch watching TV when the commercials come on. She pulls out her phone and unlocks it. She notices a new notification badge on the eyesUp app so opens it. Someone has commented on Sarah's comment from earlier in the day. User MightyMouse45 has replied with “I agree the font is all wrong. They have used a 60's themed font, but the business sells art deco jewelry. It seems thematically off.” “Ah”, Sarah thinks, that's why I didn't like that font. Another user has commented “Agreed, it looks like the font ‘Hobo Std’. It's the next comic sans - lol.” Sarah upvotes the comments and closes the comment thread and sees another notification. Her friend visualNinja23 has noticed a sign and opened a discussion thread (card?). Sarah's friend has tagged the sign as “typography”, “logo”, and “black and white” and liked/plus-ed/dig it. VisualNinja23 has commented “Awesome sign I saw today. I love the contrast.” Sarah looks over the sign and notices the font selected is a good fit for the business; a calligraphic font with generous swashes for a wedding business called “Happily Ever After”. Sarah comments on the image “I think the font selection is good. It totally fits the theme of the business.” She then likes/plus/digs the whole post. The ad break ends and so Sarah then closes the app.

Figure 3-4: An example of one of the scenarios created. Author's original composition.

Once the scenarios are created, they can then be broken down into smaller components so that specific capabilities or features could be extracted to form user stories. This is done using the user story structure, “as a *<user>* I want to *<feature>* so that *<value>*”, recommended by Milicic et al. (2012, p. 62). An example of a user story based on the scenario in Figure 3-4 would be: as a s*tudent in a visual communication course* I want to *follow the activities of a peer in my class* so that *I am made aware of the visuals they see and their thoughts on them*. These user stories are then transferred to cards (Figure 3-6) and added to a user story map. This story map contains all the features of the app that are to be included in the prototype (see Figure 3-5)

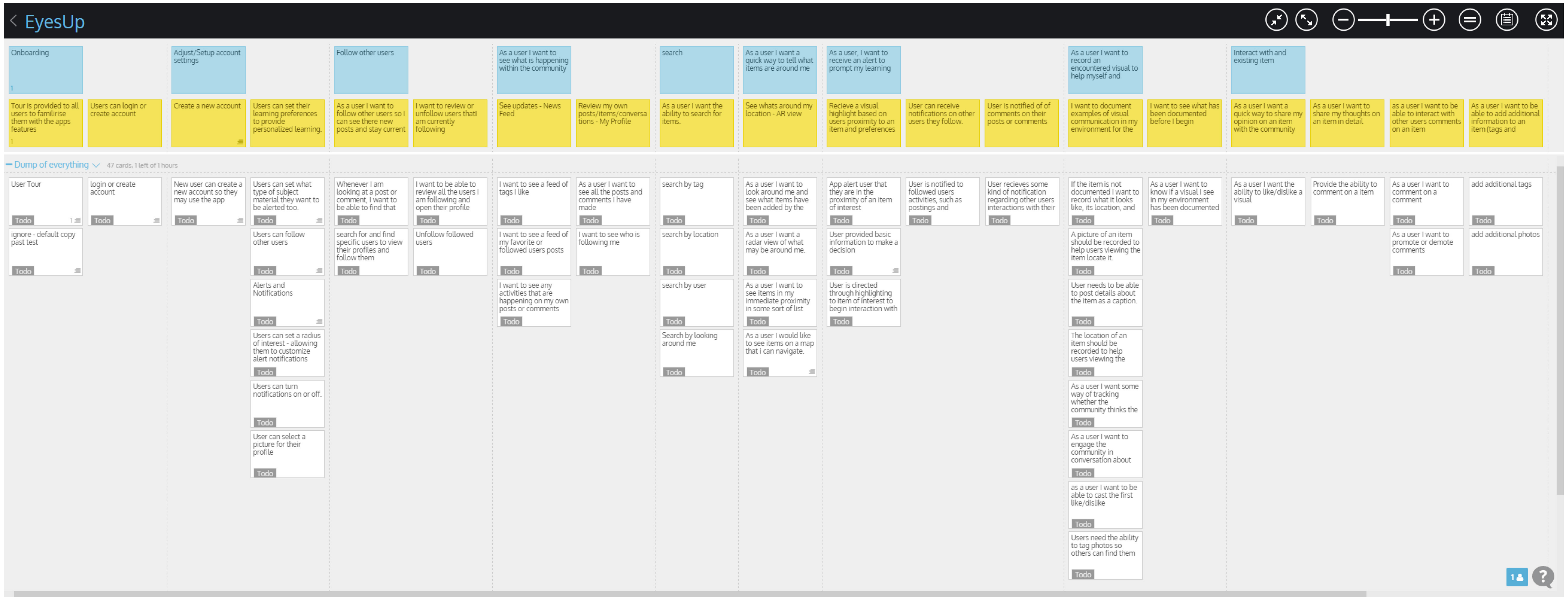


Figure 3-5: A screenshot of www.storiesonboard.com displaying the author's story map created for prototype app base on learning model and scenarios.

StoriesOnBoard (www.storiesonboard.com) is used to create the story map. This is a purpose-built development tool that mimics post-it notes, allowing for easy editing and rearrangement of digital cards (Figure 3-5). Each card in this system can be expanded to add additional detail to the associated user-story, listing any prerequisites or criteria, and noting how this feature could be tested later in stage three of the research design (Figure 3-6).

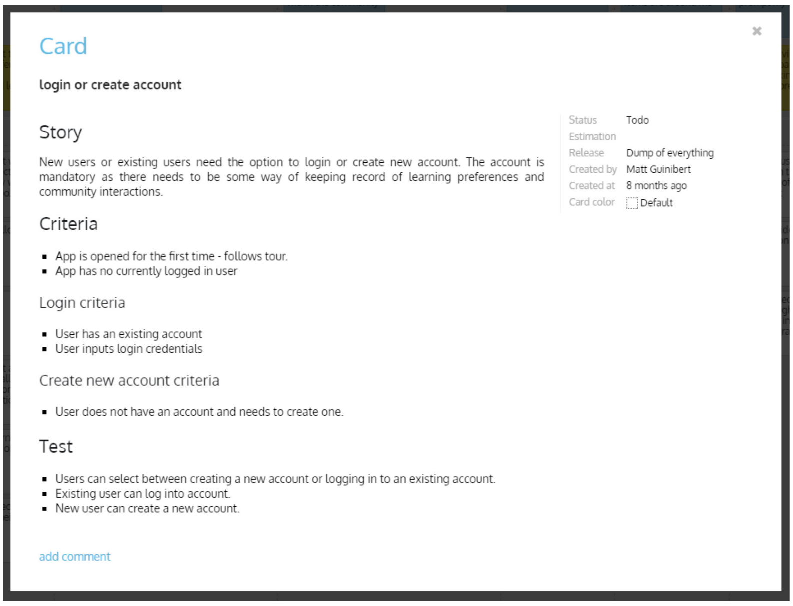


Figure 3-6: A screenshot of www.storiesonboard.com displaying the expanded view of the card at the bottom of the second column seen in Figure 3-5.

The user story cards in the user story map are then translated into low-fidelity mock screens, known as wireframes. The wireframing is undertaken through several iterations. First, the screens are designed using pencil and markers on paper (see Figure 3-7). IDEO.org (2015) and Martin and Hanington (2012) recommended paper as a good way to spur ideas, gain a deeper understanding of who one is designing for, and to work iteratively. Iterations of screens are made, rejected and refined by applying heuristic's core processes.

Figure 3-7: Three of the pencil and marker wireframes created. Author's original composition.

The paper prototypes are then translated into digital wireframes (Figure 3-8) using *Balsamiq* (www.balsamiq.com). Balsamiq is a digital design tool used in the production of digital low-fidelity wireframes. The tools provided by Balsamiq are intentionally limited to restrict aesthetic considerations, focusing instead on the placement and sizing of interface elements. Balsamiq allows for iterative design, where each screen wireframe can be versioned and iterated. This iterative workflow allows for further reflection and refinement through the application of heuristic's core processes.

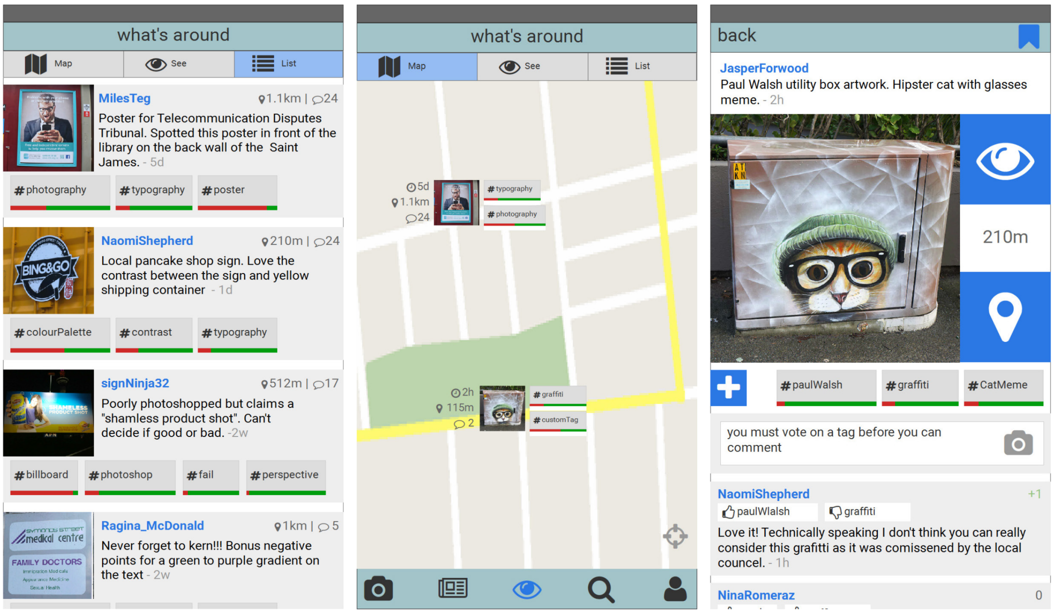


Figure 3-8: Three wireframes created in Balsamiq. Author's original composition.

As the wireframes are created, they are also added to a rapid prototyping tool called *inVision* (www.invisionapp.com) to create a low-fidelity prototype. InVision works by creating clickable, tappable, or swipeable hot spots on wireframes to mimic the functionality of an app (Figure 3-9). The prototype can then be run on a mobile device in a manner that mimics the behaviour of a native app. The use of inVision allows for both the interactive prototype and the wireframes it contains to be checked and assessed on an iPhone by the researcher throughout the process. This helps determine the user interface elements actual size and placement on a real device, and ensures the flow of the screens makes sense. Once the final Balsamiq wireframes are completed and added to inVision, the low-fidelity interactive prototype is complete.

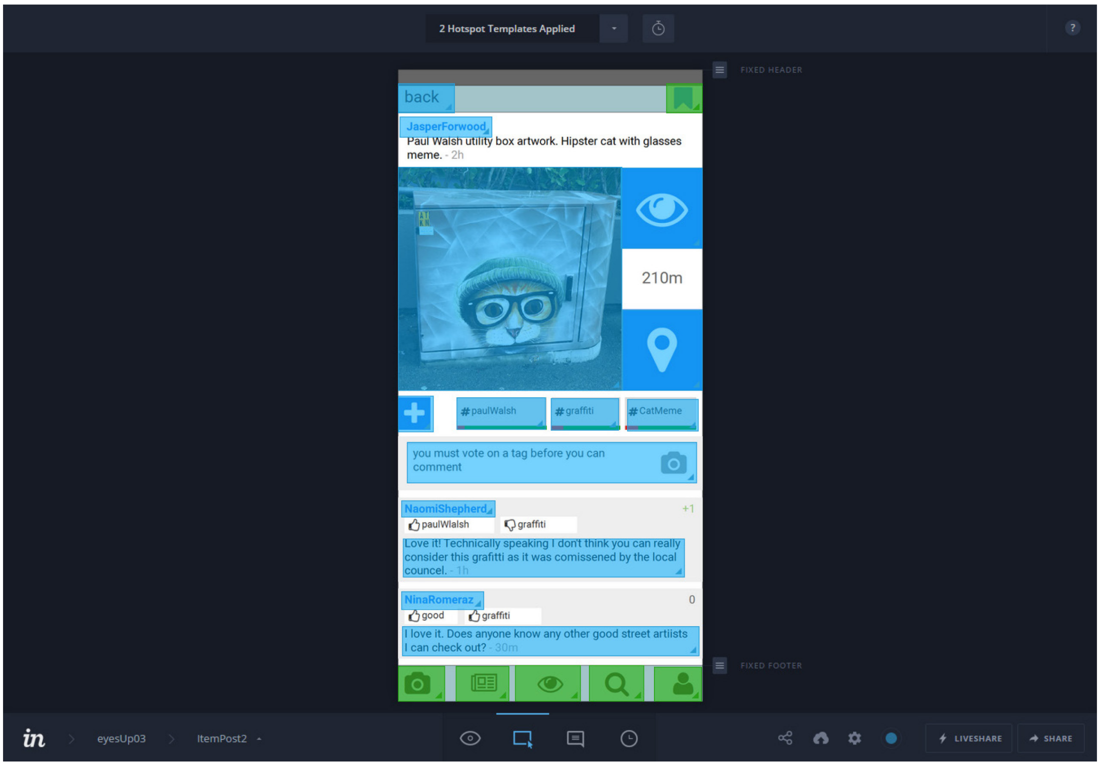


Figure 3-9: A screenshot of one of the author's compositions created in inVision. Tapable hotspots highlighted in blue and green.

3.6.3 Stage 3: Testing

Stage three of the research design represents heuristic inquiry's requirement to incrementally increase knowledge (Moustakas, 1990), and UCD's requirement to design iteratively (Vredenburg et al., 2002). Usability testing is used to gain feedback from potential users on the tentative learning model and low-fidelity prototype. Following testing, second iterations of the learning model and prototype are created based on the test's results. This phase marks a shift from inductive logic to deductive logic, allowing the ideas generated in stage one and two of the research design to be tested, and then potentially validated and refined.

The first consideration in usability-testing is planning the scope and purpose of the study (Rubin & Chisnell, 2008). In this research, the purpose is to both refine and potentially validate the low-fidelity prototype app and tentative learning model. To further refine the goals of usability testing it is recommended to know which questions and concerns will be illuminated by the testing (Barnum, 2011; Rubin & Chisnell, 2008). For this study, the goal is to collect data on the viability, preferences, recommendations, errors, and satisfaction levels of the low-fidelity prototype. A further goal is to probe the participants' thoughts and experiences relating to visual literacy learning and the pedagogical assumptions that underlie the tentative learning model. Because the capacity of usability testing is limited by its key tenets of users performing representative tasks, the aforementioned goals of this study are beyond its function. Therefore, this research includes an interview component to the usability testing sessions. The addition of an interview component to usability testing is common practice in UCD (Martin & Hanington, 2012) and is also recommended by Moustakas (1990) for heuristic inquiry. The usability testing sessions are therefore split into three parts, namely, a warm-up, followed by scenarios with embedded tasks, and then an interview. These three combined components comprise the usability test session referred to throughout this thesis.

To begin the usability test sessions, participants are asked warm-up questions. This is a common practice used to establish rapport with participants by asking questions that can be answered easily and at some length (Qu & Dumay, 2011). In this study, this involves asking open-ended questions that may inform the viability of the app and learning model. As these questions are asked before participants are introduced to the prototype app, participant responses are not biased by their introduction to the app and experience of it. Therefore, responses can potentially be used to support or reject the premise of this research.

The introduction is followed by a series of scenarios that involved participants using the prototype app to attempt tasks. Test scenarios are stories that provide context and motivation for tasks that participant's attempt, and sometimes define the possibilities of how these tasks may be completed (Tan, Liu, & Bishu, 2009). Tasks are an essential requirement of a usability test as they allow for the observation and recording of representative users attempting to perform representative tasks for analysis at a later stage (Dumas & Fox, 2009; Lazar et al., 2017).

The scenarios are based on the user personas (Figure 3-3), scenarios (Figure 3-4), and story map cards used in development of the low-fidelity app (Figure 3-6). This practice is recommended by U.S. Department of Health and Human Services (2016d) as it ensures that the prototype is tested against its intended design objectives. In this research, the tentative learning model is also accounted for in the creation of scenarios, as this serves as the guiding set of principles in the app's creation. This allows for data to be collected, not only on the low-fidelity app itself, but also on the tentative learning model.

As participants complete scenarios they are asked open ended questions about the task they had completed, a practice that is referred to as *retrospective think aloud* (RTA) (Olmsted-Hawala & Bergstrom, 2012). Through RTA, data on the participant's thoughts can be collected without distracting them from completing tasks. However, RTA is noted to have a drawback – that is, that participants may struggle to remember tasks (Olmsted-Hawala & Bergstrom, 2012). This is alleviated by immediately asking the follow-up questions on each task's completion to ensure that captured thoughts are fresh. For tasks involving text entry or selections, participants are asked to think out loud while performing the task as a means of capturing their inputs. This technique is often employed in usability testing and is referred to as *concurrent think aloud* (CTA) (Dumas & Fox, 2009; Olmsted-Hawala & Bergstrom, 2012).

The third and final section in the usability-testing sessions is an interview component consisting of a series of open-ended questions. These questions allow flexibility to improvise follow-up questions based on the participant's responses (Kallio et al., 2016). This reciprocity allows the researcher to ask participants to clarify or further expand on ideas as they are presented (Barriball & While, 1994). The questions are designed to elicit responses relevant to the tentative learning model's pedagogical assumptions, and collect data on participants' experiences and perceptions relating to them (see Appendix D). Participants' perceptions of the low-fidelity prototype are also questioned to gather data on the prototype itself and the pedagogical assumptions embedded within.

3.6.3.1 Participants

UCD and usability testing practice recommends participants should be representative of those who will actually use the software under scrutiny (Dumas & Fox, 2009; Martin & Hanington, 2012). Therefore, students who were enrolled in an introductory visual communication course at Auckland University of Technology were invited to participate in the study. The course was selected for its size, having over 250 students, and for its diverse student base from a wide range of degrees and faculties, including Communication Studies, Creative-Technology, Hospitality, Tourism and Events, Arts, and Business. Potential participants are first contacted and invited to respond through email (Appendix B). This email included an attached information sheet (Appendix A), which outlined the studies purpose, processes, estimated time, dates, and privacy details, and an attached consent form (Appendix C).

Of the respondents to the email invitation, five were selected for the usability-testing session based on the Nielsen-Landauer formula for usability-testing. The Nielsen-Landauer formula states that between three to five participants will encounter 70% to 90% of the usability problems (Nielsen & Landauer, 1993). Once five participants are exceeded, the additional resources and effort needed to yield a comparatively small amount of new data is inefficient and ineffective (Nielsen, 2000, 2012). This small number also works well for heuristic inquiry which is interested in rich (qualitative) and detailed explications, and not metrics data (Moustakas, 1990).

3.6.3.2 Tools

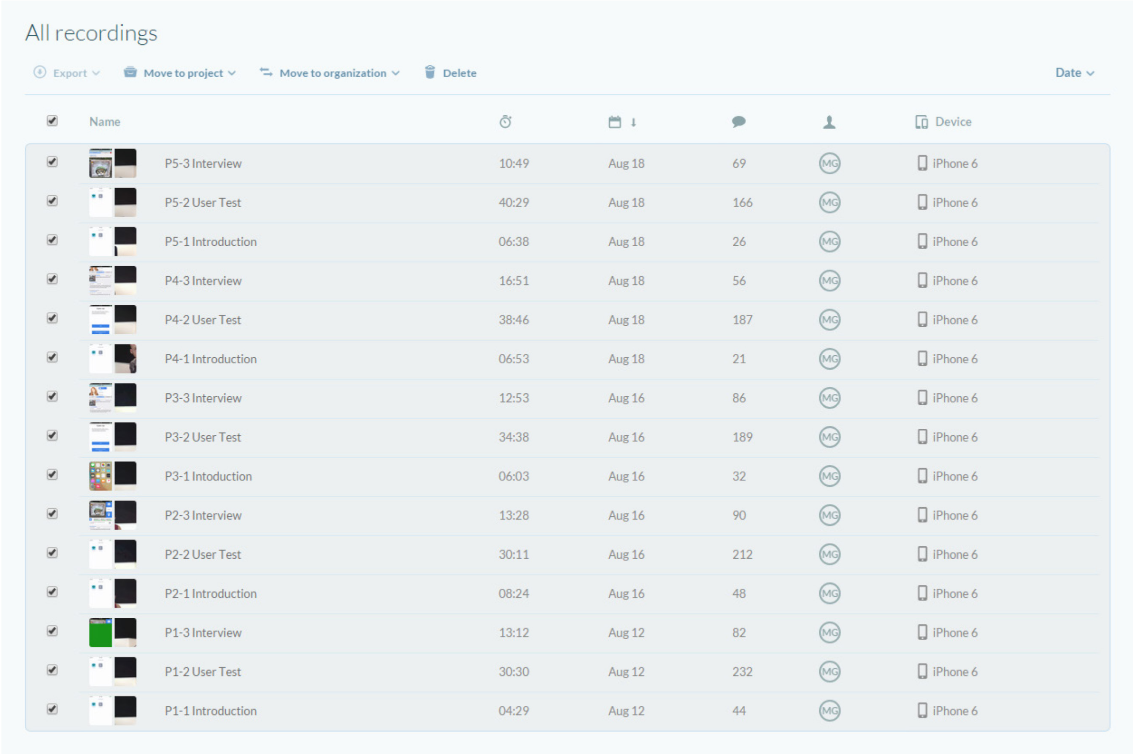
A combination of tools is used throughout the usability-testing sessions. The combination of tools allows for the low-fidelity prototype to be tested on a mobile device and recordings to be made of both the prototype in use and of the participants.

Two software platforms are used to collect data, inVision (www.invisionapp.com) and Lookback (lookback.io). InVision is used to run the low-fidelity prototype locally on an iPhone 6, creating an experience like using a native iOS app. Lookback is a purpose-built usability testing capture platform, and is used to capture two simultaneous streams of video and a single stream of audio. One stream of video is of the iPhone 6's screen running inVision and the other stream is of the participants' person. The hardware used is a MacBook Pro running OSX connected to an iPhone 6 and a zoom H6 recorder with a MS capsule microphone (Figure 3-10). The location selected as the testing room is a purpose-built space for the use of private interviews.

Figure 3-10: The test equipment setup used for recording usability tests. Author's original composition.

3.6.3.3 Analysis

The analysis procedures this study utilises are taken from both heuristic inquiry and usability testing. Moustakas (2014) recommended that the analysis of the data begins with processing and organising all the recorded data. This is achieved by ensuring all recordings are uploaded to Lookback's web-based analysis tool and that all recordings are labelled and organised (Figure 3-11). Each participant's usability test session is broken down into the three stages of the introduction, scenarios, and interview.


All recordings

Export | Move to project | Move to organization | Delete | Date

Name	Duration	Date	Comments	User	Device
P5-3 Interview	10:49	Aug 18	69	MG	iPhone 6
P5-2 User Test	40:29	Aug 18	166	MG	iPhone 6
P5-1 Introduction	06:38	Aug 18	26	MG	iPhone 6
P4-3 Interview	16:51	Aug 18	56	MG	iPhone 6
P4-2 User Test	38:46	Aug 18	187	MG	iPhone 6
P4-1 Introduction	06:53	Aug 18	21	MG	iPhone 6
P3-3 Interview	12:53	Aug 16	86	MG	iPhone 6
P3-2 User Test	34:38	Aug 16	189	MG	iPhone 6
P3-1 Intoduction	06:03	Aug 16	32	MG	iPhone 6
P2-3 Interview	13:28	Aug 16	90	MG	iPhone 6
P2-2 User Test	30:11	Aug 16	212	MG	iPhone 6
P2-1 Introduction	08:24	Aug 16	48	MG	iPhone 6
P1-3 Interview	13:12	Aug 12	82	MG	iPhone 6
P1-2 User Test	30:30	Aug 12	232	MG	iPhone 6
P1-1 Introduction	04:29	Aug 12	44	MG	iPhone 6

Figure 3-11: A screenshot of lookback.io demonstrating the organisation of the recordings.

Heuristics then calls for the researcher to undergo a period of immersion in the data (Moustakas, 2014). This is achieved by having the primary researcher transcribe all the audio and make notes. Lookback is used to transcribe all the recording as it allows for the transcription to act as subtitles for the recordings, a text searchable database that can be used to call up exact moments in the recordings, and can also be exported in tabular format (Figure 3-12). This same system is used to capture any notes made in relation to the participant's actions while using the low-fidelity prototype app.

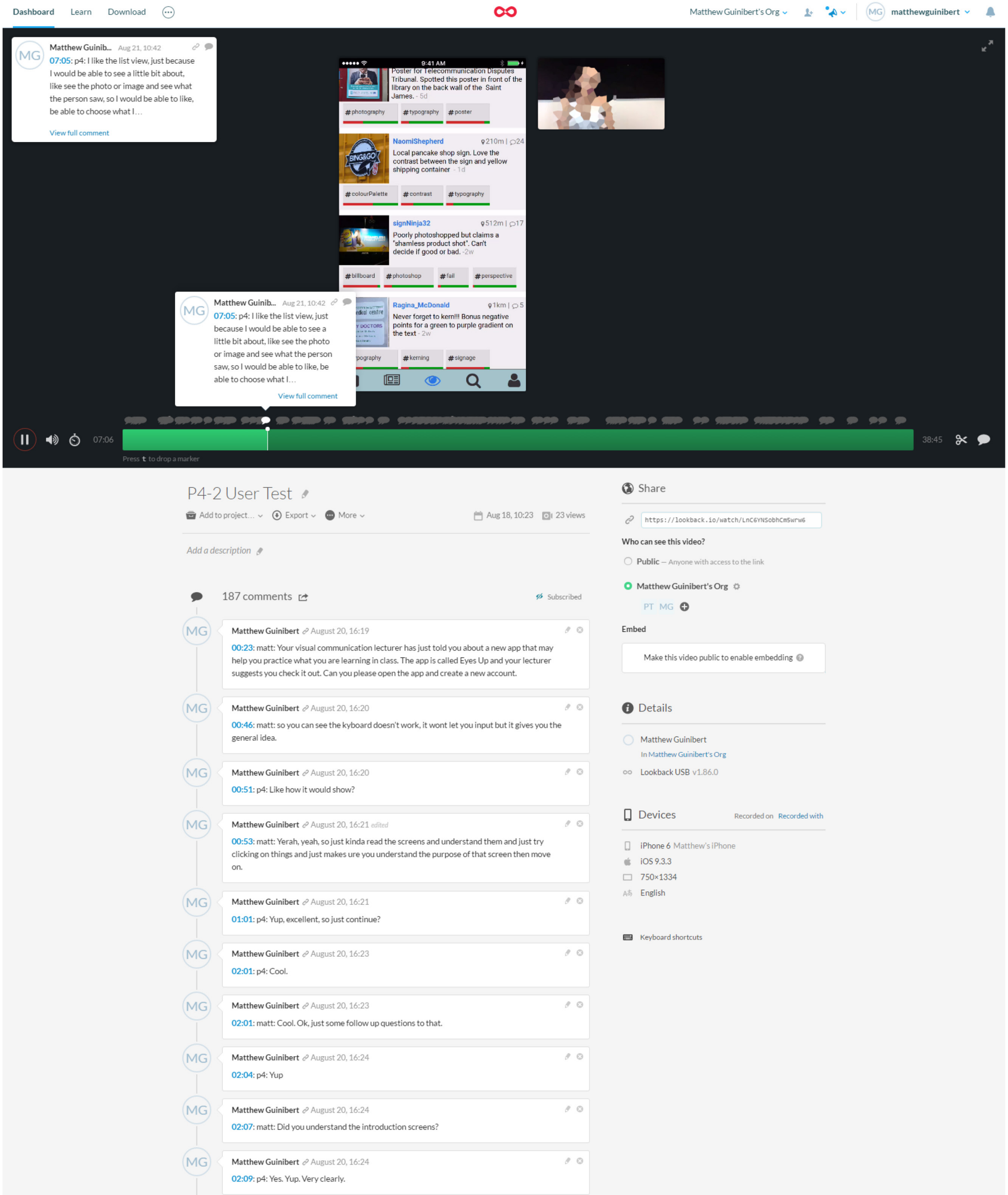


Figure 3-12: A screenshot of lookback.io's interface used for analysing the recordings.

The researcher then sets aside the data for a period to undertake what Moustakas (1990) describes as a *period of rest*, where the research spends time away from the data. This period of rest aids the core processes of heuristic inquiry, in particular, this helps indwelling and focusing, allowing the researcher to tap into tacit knowledge and intuition. This also helps the researcher begin to identify and explain constituent parts of other's experiences (Moustakas, 1990; Sela-Smith, 2002).

Once organised and rested, the data is divided into the three sections of the usability testing sessions so that each section could be further analysed using different procedures. This was necessary as the approaches and objectives of each of the usability testing session's sections are different. The response captured by the warm-up and interview questions are analysed using procedures recommended by Moustakas (1990) for heuristic inquiry, while the scenarios are analysed using a combination of heuristic inquiry procedures and usability testing procedures as recommended by the U.S. Department of Health and Human Services (2016f).

An analysis of the responses to the warm-up and interview questions using the heuristic processes of indwelling and focusing is used to begin explicating the qualities and themes of the participants' experiences. Moustakas (1990) recommended that the explication process produce statements that depict the experiences of the participants. From these statements, textual descriptions are written that explain the meaning of the thoughts and experiences captured from the participants. These textual descriptions are then compared back to the raw data to check that they are representative of the participants' thoughts and experiences. Moustakas (1990) then recommended a return to the raw data to identify examples, such as quotes, to be presented with the textual descriptions. The quotes and textual descriptions are then combined to produce descriptive answers to the questions posed in the warm-up and interview sections of the usability testing sessions. The outcome of this undertaking are manifested in Sections 5.2 and 5.4 of the results chapter.

The actions and responses collected from the scenario section of the usability tests are analysed using the heuristic inquiry procedures discussed in the preceding paragraph and by additionally using the guidelines offered by the U.S. Department of Health and Human Services (2016f) to identify usability issues. The usability issues consist of any mistakes, hesitations, and pathway deviations while undertaking the scenarios issued. These usability issues are used to aid in the explication of statements that depict the experiences of the participants. The outcome is a usability report of the issues participants encountered and their thoughts and experiences of the low-fidelity prototype app. This is reported in Section 5.3 of the results chapter.

3.7 Chapter Summary

This chapter outlined the methodological framework of this research, which synthesised an approach using heuristic inquiry and user-centred design to sequentially set and solve the research questions. Moustakas' (1990) phases of heuristic inquiry form the overarching structure for the research design, with UCD methods to supplement the creative synthesis phase. Methods are arranged so that knowledge can be incrementally increased over the course of the research, accompanied by a logic shift from inductive to deductive, so that ideas generated may be tested and refined. The arrangement of these methods produces a research design that involves three sequential stages, where each stage builds on the last. The first stage aims to synthesise a tentative learning model. The second stage aims to create a prototype for a smartphone application based on the tentative learning model. The third stage aims to test the outcomes of the first two stages, to potentially validate and refine them.

Chapter 4: Learning Model and Prototype

4.1 Introduction

This chapter reports the outcome of phase one and two of the research design presented in Chapter 3. Stage one of the research design was concerned with the explication of a tentative learning model which described how everyday encounters with visuals can be leveraged as a visual literacy learning opportunity by providing learning support. The outcome of stage one is reported in Section 4.2 below. Phase two of the research design was concerned with the practical application of the tentative learning model by creating a prototype for a smartphone application. This is reported in Section 4.3.

4.2 Tentative Learning Model

This section describes the tentative learning model, with each pedagogical assumption of it accompanied by a rationale. The learning model is comprised of an overarching or core pedagogical assumption, accompanied by a further nine pedagogical assumptions and their sub points that describe how the core assumption may be achieved. The core pedagogical assumption of this learning model is that:

Persistent access to support and collaboration with more capable peers is required for novice learners to learn visual literacy decoding skills from visuals encountered in their everyday environment.

This model operates on the presupposition that visuals are a ubiquitous resource present in a learner's everyday environment, and that these visuals can be used to gain visual literacy. However, learning from these resources is outside a novice learner's means without persistent support in the form of guidance from, or collaboration with, more capable peers. The goal of this tentative learning model is to provide recommendations for an approach to enable learners to learn from the imagery that constantly surrounds them in an informal, ubiquitous, decentralised, and collaborative manner.

1) Visual analysis provides a means for learners to more deeply engage with examples of visual communication within their environment and learn from them.

Visual analysis is an effective means of learning and practising visual literacy skills. Imagery that is analysed by a learner is more likely to be remembered, resulting in learning. Visual analysis also helps develop critical and reflective skills. These critical and reflective skills in turn inform visual analysis, thereby improving a learner's skills each time an analysis is undertaken.

2) Learning must be inclusive of the different understandings of visual literacy.

While this learning model is limited to visual analysis, it does not advocate any one single interpretation or understanding of what visual literacy is over another. In this sense, the model can be considered inclusive. This allows for a multitude of understandings and interpretations to co-exist, as directed by the learning community.

3) Learning visual literacy is a collaborative activity.

As this learning model takes place in an informal setting, there is no formalised curriculum and no specifically designated teacher. Instead, learning takes place as learners come together to learn from one another. Ideally, images would be analysed by multiple learners, seeing gaps or errors in information filled by a community's pooled knowledge. Thus, learners of different backgrounds and skill levels alternate between receiving, refining, and imparting knowledge. Collaboration provides peer support, allowing learning to take place within a learner's zone of proximal development.

3a) Provide a community to facilitate collaborative learning. Community provides a means for learners to come together so that collaborative learning can take place. The community should promote interactions that will lead to learning within that community, while minimising interactions not related to learning visual literacy skills.

3b) Make learners aware of social factors. Learners within the learning community need to be made aware of social factors, such as if other learners are presently active, and any actions other learners have performed. Also, there needs to be awareness of any other learning activities and how they are progressing.

3c) The learning community should be decentralised. The community provided for collaborative learning should not include a centralised person or control mechanism exercising control over the learners within the community. Instead, learners are required to make their own independent decisions about their learning and the direction of the community.

4) Learning is triggered by contingent encounters with examples of visual communication in a learner's environment.

Learning takes place because of encountered artefacts. The artefacts are forms of visual communication. These artefacts need to meet two criteria. First, they need to exist within a physical environment in a manner that allows all members of the learning community who physically pass through that environment to encounter the artefact and experience it. This ensures that visuals can be experienced in their original environment by anyone in the community who happens upon the visual's location. Second, these visuals must be able to be documented and shared with the learning community, so as to adhere to the third pedagogical assumption. This provides a starting point in the visual analysis process and provides a foundation, node, or conversation for the community to begin building upon.

5) Learners need to examine and investigate their environment's examples of visual communication as a means of learning.

Pedagogical assumption four states that learning takes place because of encountered artefacts. This pedagogical assumption accounts for encounters with visuals that learners have identified by their own volition. Through examination and investigation of encountered visuals, learning may be triggered as described by pedagogical assumption four. This is in purpose of discovering relationships between existing background knowledge and unfamiliar content and concepts.

6) Provide a means to highlight or direct learners to examples of visual communication.

While learners may identify examples of visual communication within their environment unaided (as described by pedagogical assumption five), they also need support in identifying examples. This should be facilitated through a mechanism of highlighting or directing learners to examples within their environment as identified by the learning community. This provides learners support in their zone of proximal development, and may also help overcome issues of habituation. Essentially, highlighting and directing are mechanisms to alert and trigger learning from the potentially countless examples of visual communication a learner might otherwise overlook.

7) Provide ubiquitous access to learning.

Learning must be accessible anytime and anywhere. This provides flexible and dynamic learning that can take advantage of the chance learning opportunities that present themselves as learners move through their environments. Learning when implementing this learning model needs to match the ubiquity of visual communication.

8) Provide context-aware learning.

Examples of visual communication encountered should be accompanied by additional information based on context. As context can influence visual analysis, context-aware learning may provide additional support. Context-awareness can also be utilised to help document encountered examples of visual communication, for example by capturing location, direction, time, weather, velocity, and lighting.

9) Learning needs the ability to be personalised to accommodate a learner’s environment, goals, interests, and preferences.

Learning under this model requires learning to be personalised. This helps maintain a learning environment which does not dictate any one understanding of visual literacy. Learning within a decentralised system requires learners to have the ability to be in control of their learning, rather than have control exercised over them. This allows learners to pursue their own objectives, goals, and understandings, within environments of their choice.

9a) Personalised learning also needs to include the means to limit learning. Examples of visual communication are so pervasive they are almost unavoidable. If learning were to take advantage of every example of visual communication in a learner’s environment, they would not be able to go about their day without persistently being interrupted. Therefore, personalised learning should also be used to limit learning opportunities based on a learner’s environment, goals, interests, preferences, and context. Additionally, control to start and stop the learning should be provided.

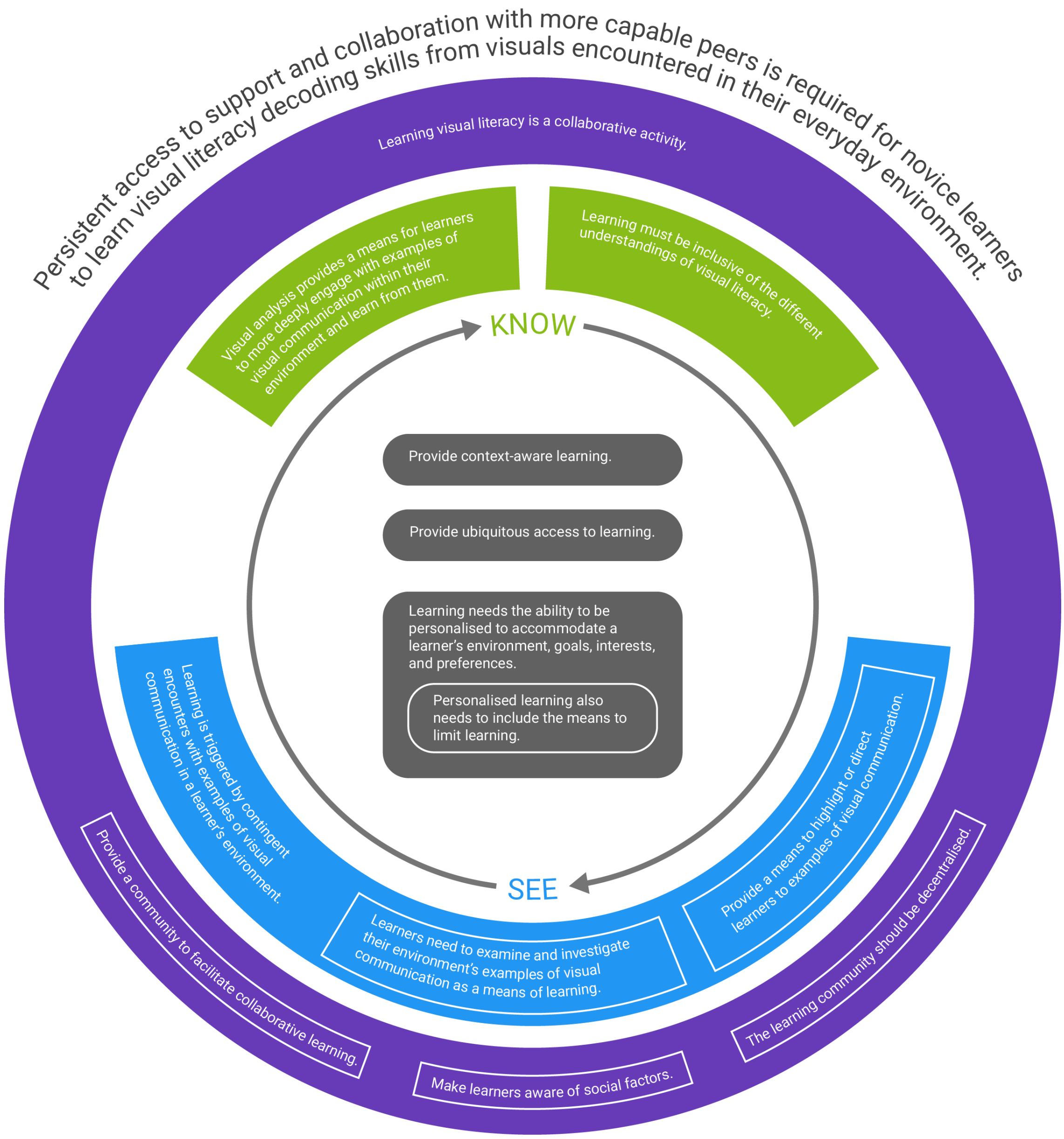


Figure 4-1: Diagram of the tentative learning model. Author's original composition.

4.3 Low-Fidelity Prototype

The app created for the low-fidelity prototype, called "EyesUp", is a practical exploration of the tentative learning model presented in the preceding section. It is the outcome of stage two of the research design. The app provides a means for users to capture and share visuals they notice in their environment with the app's community. Shared visuals are located for other users to experience in person. The shared visuals create an artefact for the community to discuss. Learning occurs as the app's community receive and impart ideas relating to the shared visuals. The app provides settings to have the visuals highlighted, based on preferences and physical proximity to the visuals.

Figure 4-2: The EyesUp logo. Author's original composition.

The low-fidelity prototype app is explained in greater detail in the following three sections. The first section (Section 4.3.1) reports the technological concerns of the app. The second (Section 4.3.2) provides an overview of some of the key screens of the low-fidelity prototype, which are used to explain the app's use and feature set. The third section (Section 4.3.3) provides links to the low-fidelity prototype used by participants during the usability testing sessions.

4.3.1 Technical concerns

Selwyn (2011) claimed that educational technologists can be overly optimistic in what technology can achieve. Puentedura (2006a, 2006b) noted that for educational technology to achieve the best possible outcome, technological affordances must be considered. Therefore, this section outlines the key technological considerations and limitations that were factored in the creation of a low-fidelity prototype. These same limitations also informed the second iteration of the prototype following stage three's usability testing.

The first decision in implementing the tentative learning model was platform choice. One of the primary concerns of the tentative learning model is to provide persistent access to support. Therefore, a "mobile" or "smartphone" application, commonly referred to as an app, was rationalised as an appropriate platform. Most Millennials have both access to such technology, and a desire to be constantly near their mobile devices (Gikas & Grant, 2013). These aspects provide access to the anytime and anywhere capabilities of m-learning, and will allow the pedagogical assumptions regarding highlighting and context-aware learning in the tentative learning model to be achieved.

To set the limitations of the prototype app, Bootstrap3 (http://getbootstrap.com) was chosen as the standard for the interface. Bootstrap3 is a library of HTML, CSS, and JavaScript (commonly referred to as a front-end framework) that is used to design the front-end experience of websites, mobile websites, and web apps. Also, through tools such as PhoneGap (https://build.phonegap.com) or Apache Cordova (https://cordova.apache.org/), Bootstrap3 can be packaged as a native app. Essentially Bootstrap3 is a design standard used as a starting point for development, providing interface elements and layout tools that an interface will require. While this research only attempted prototypes, these prototypes have realistic limitations and are an accurate representation of what is achievable given current technology. This was done by limiting interface decisions to what is achievable on Bootstrap3.

The community aspect of the prototype is achieved using a social media paradigm. Social media are interactive applications where content is generated and shared online by users and their interactions (Kaplan & Haenlein, 2010). In the case of the prototype, the social media mechanics (except for two, explained later in Section 4.3.2.2) are based on selecting ideas from current social media platforms, namely, Facebook (www.facebook.com), Instagram (www.instagram.com), Stack Exchange (www. stackexchange.com) and Reddit (www.reddit.com). These ideas include: user accounts or profiles, posting comments, posting pictures, commenting on posts, replying to comments, up-voting and down-voting comments, liking or disliking posts, following topics of interest, following users, and providing aggregated views of user-generated content. By using existing mechanics and ideas from successful and widely used social media platforms, there will be a greater chance that users will have encountered these mechanics before, and will therefore be familiar with the functionality of the prototype. As Krug (2000) argued, this replicating of mechanics across apps makes them easier to use, or intuitive, because users can transfer behaviours learned from one platform over to another. This also sets realistic limitations for the prototype, as these social media mechanics have already been achieved in the aforementioned apps.

The prototype also makes use of augmented reality (AR). AR is a kind of computer-mediated reality, whereby a view of a real physical environment is modified or “augmented” by a computer (Azuma, 1997). AR often appears in apps as a live view taken through a smartphone’s camera of a real physical environment, with some computer-generated overlay to augment what the user sees. AR in this research is envisioned as a means to highlight visuals within a user’s environment. To ground this research in what is achievable, the capabilities of Wikitude (www.wikitude.com – an augmented reality plugin for developers to use in the creation of apps), were used to set limitations for the prototype. Specifically, Wikitude’s ability to overlay customisable and interactive points of interest (POIs) on a physical environment was used to envisage how the AR components of the prototypes would work.

4.3.2 Overview of the low-fidelity prototype

This section presents the low-fidelity prototype using its structure and screens to provide an overview of the app and its features. As the low-fidelity prototype consists of sixty screens, those included in this section only cover the areas of the app that were key to the usability-testing sessions. To see all the screens, Section 4.3.3 includes links to a working version of the prototype.

4.3.2.1 Overview of the information architecture

The structure of the app is built around interacting with the content (Figure 4-3). The content is produced by the app's users and appears as 'posts', much like Facebook or Instagram.

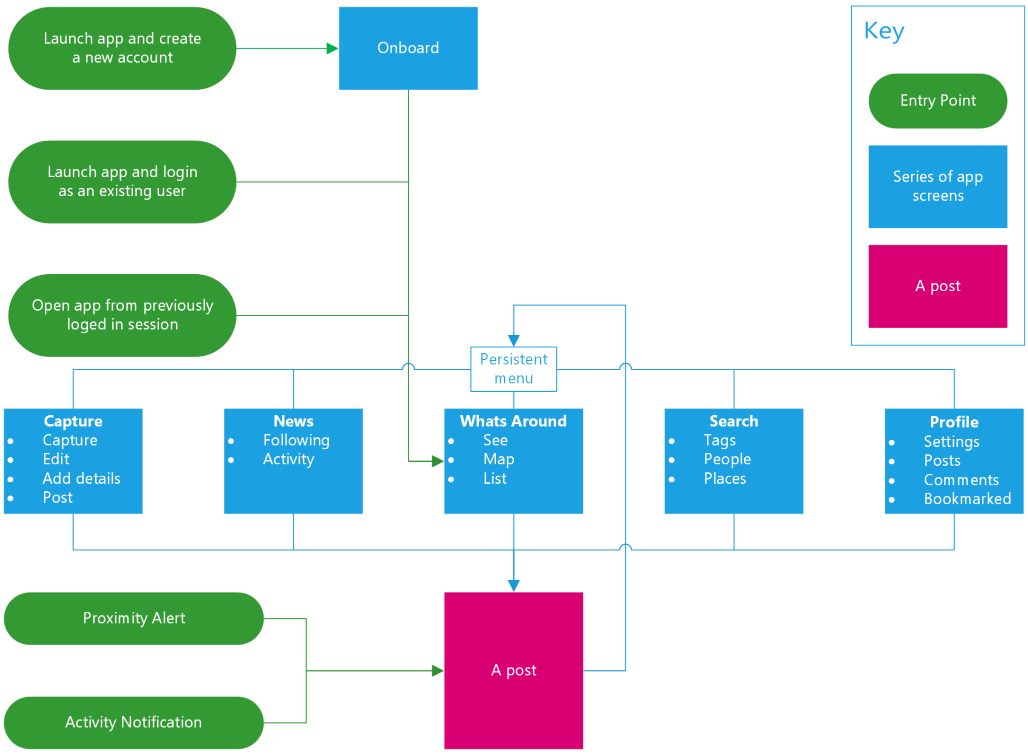


Figure 4-3: Overview of the entry points and key areas of the low-fidelity prototype and how they connect. Author's original composition.

Content in the app is created, organised, and interacted with by several different means. These different means have been grouped into five areas of the app, which can be accessed through a persistent menu (Figure 4-4). There are two means to begin engagement with the app. The first involves the user launching the app, whether this be the first time they are using it, or whether they launch the app as an already logged-in user. This will guide the user to the 'what's around' screens of the app. The second means to begin engagement is through a prompt in the form of a notification, which will direct a user to a 'post'. From both the 'what's around' and 'post' screens, a persistent menu at the bottom of the screen is provided to navigate to all other areas of the app (Figure 4-4).

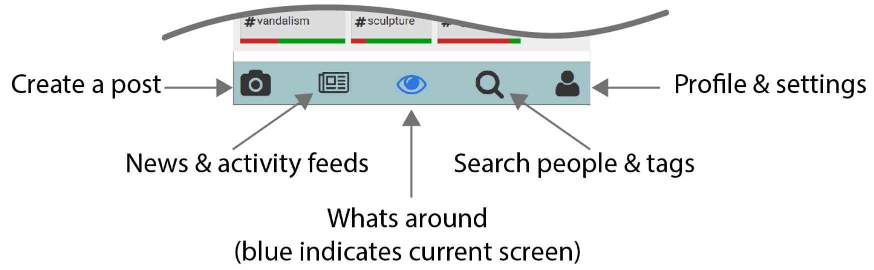


Figure 4-4: The persistent menu at the bottom of the app's screen. Author's original composition.

4.3.2.2 Post screen

The 'post' screen (Figure 4-5) displays a single captured visual and everything that relates to it. The post screen is the nexus point for the app's community and content they create. As this is the primary screen where ideas are imparted and received, it is one of the most important screens of the app.

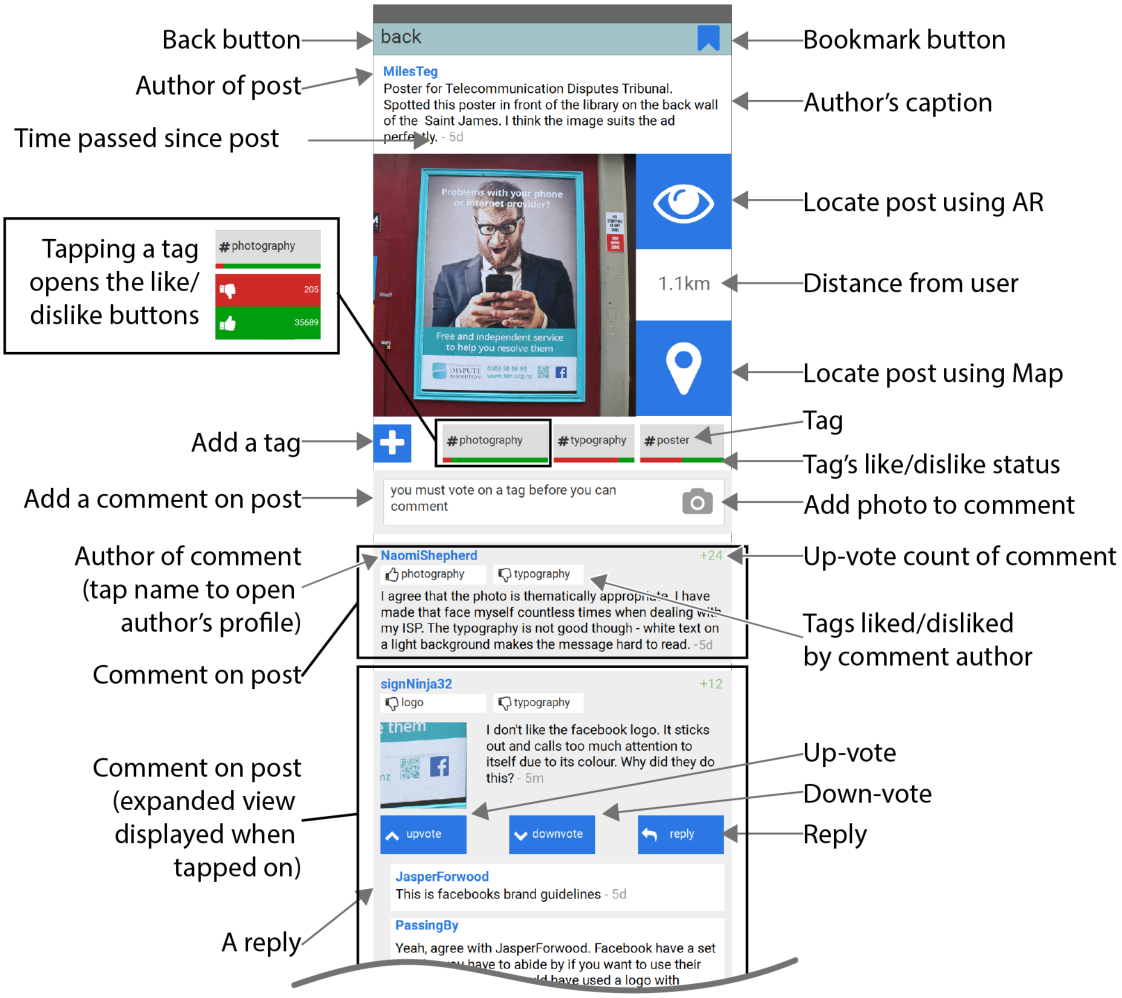


Figure 4-5: One of the 'post' screens in the low-fidelity prototype with labels to describe some of its features. Author's original composition.

The post screen allows one to view the opinions and critiques of other users, comment on the visual, reply to others' comments, up-vote and down-vote other's comments, like or dislike tags regarding the visual, add new tags, bookmark the post, and to access locational information on the post.

The features of the post screen follow similar mechanics to many existing social media experiences such as Facebook, Instagram, Stack Exchange, or Reddit. However, there are two important exceptions to the normal social media experience present in the post screen. The first is that there is no ability to like or dislike a post as a whole. Users must like or dislike tags associated with the post. Tags are user defined and any user can add a tag to a post. The total of likes and dislikes for each tag are shown under each tag as a red and green bar. This provides a fast way for users to critique visuals and provides a glanceable or simplified deconstruction and critique of a visual. This system also creates a community-generated taxonomy for critiquing images. The second exception is that users must like or dislike a tag associated with a post before they can comment. A specific user's like/dislike status of a tag on a specific post is displayed next to any comment on that specific post the user makes. The user's like/dislike status of a tag on a specific post remains anonymous until that user comments on the post. Displaying the like/dislike status of a tag is intended to provide a focus for individual comments and the replies to them. The tagging of a comment with the like/dislike status also provides a glanceable summary of the commenting author's position on the post for each comment made.

4.3.2.1 What's around

In the 'what's around' screens, 'app', 'see', and 'list' (Figure 4-6) allow users to have posts highlighted in their proximity that other users have made. The 'what's around' screens act as aggregators for the community generated posts, displaying posts based on the proximity to the user.

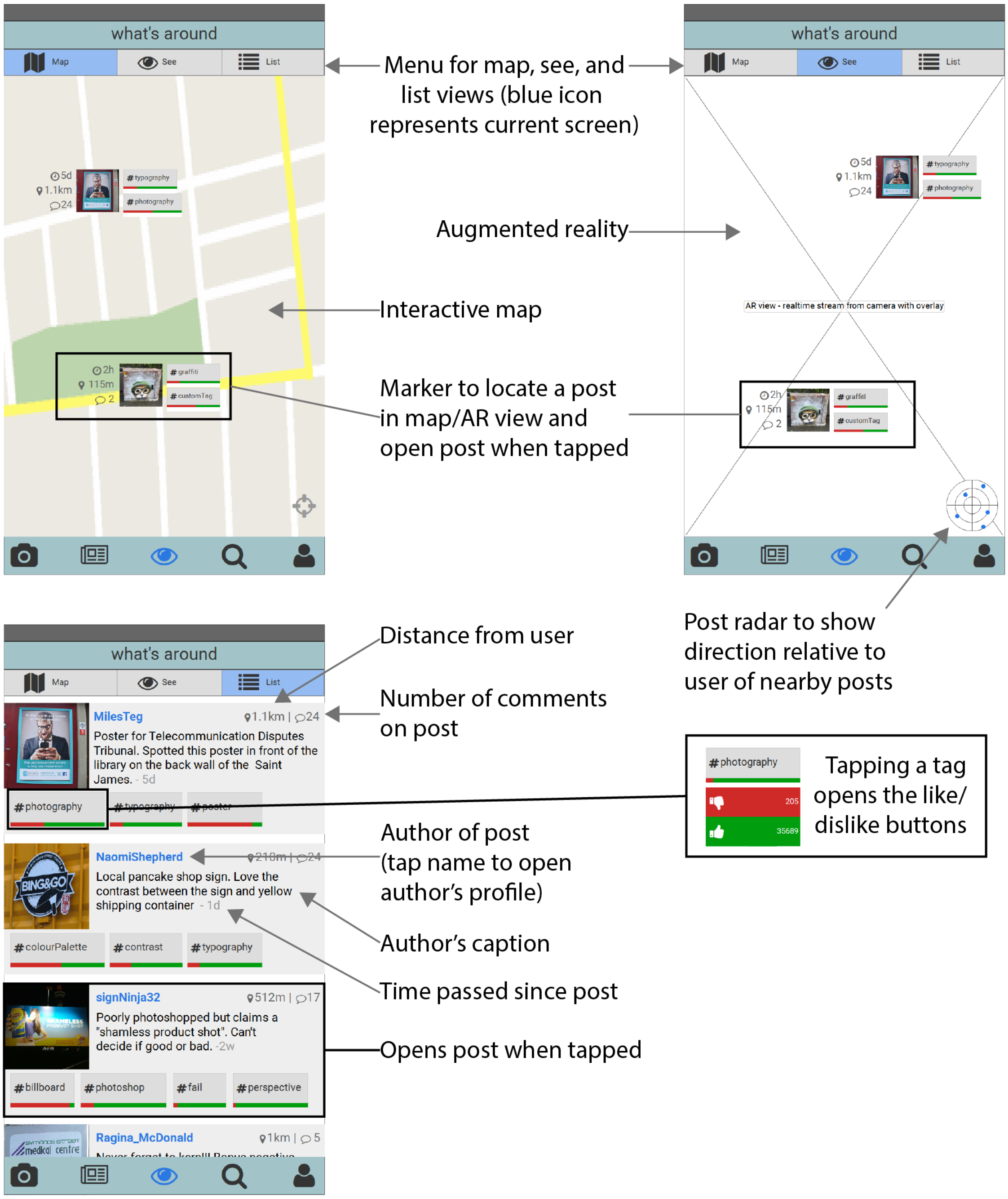


Figure 4-6: The 'what's around' section of the low-fidelity prototype, showing the 'map', 'see', and 'list' screens. Author's original composition.

The 'see' screen is an AR view comprised of a live view of the smartphone's camera, overlaid with points of interest (POI). The POIs are the posts other users have made, and consist of a thumbnail of the post and the most liked/disliked tags associated with the post. The 'see' screen will point out the location of the posts to users to help locate them in their environment, so users may experience the visual in person. The 'see' screen opens by default when the app is launched. The 'map' view screen provides a map of the user's environment with POIs overlaid. The POIs follow the same format as the AR view consisting of a thumbnail of the post and the most liked/disliked tags associated with the post. This provides an alternate means to the 'see' screen for users to orient themselves to posts. The third screen provides a list view of posts in the proximity of the user, sorted so that those closest appear at the top of the list.

4.3.2.2 Capture

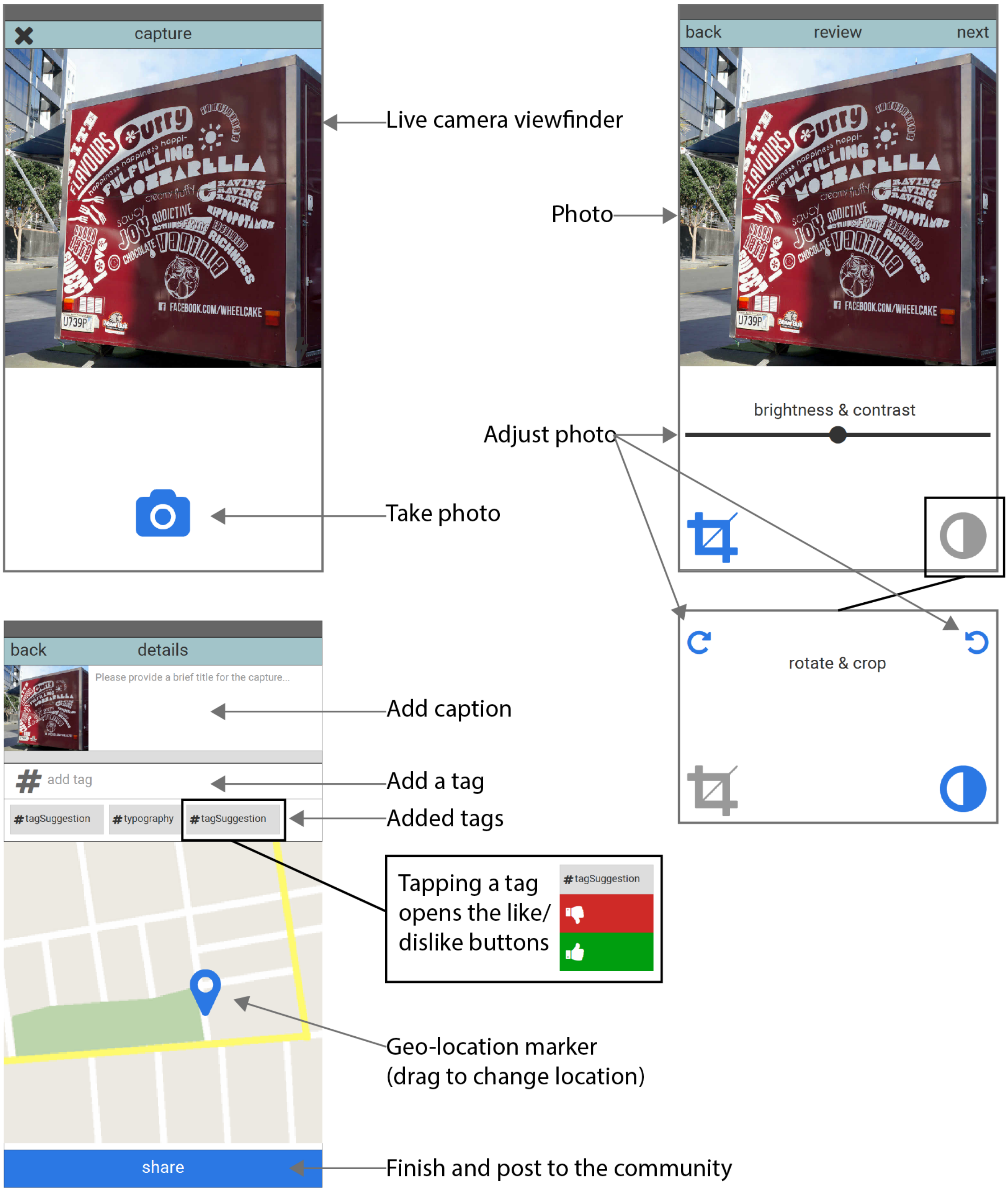


Figure 4-7: The 'capture' screens allow users to take a photo of a visual and add a caption, tags, and adjust geo-location. Author's original composition.

The 'capture' screens are how a user creates a post. Users can take a photo of a visual they have noticed in their everyday environment and add a caption, tags, adjust geo-location, and then share this with the app's community as a post. The ability to apply post-effects to photos taken in the cpature screens is intentionally limited so that they may be as close to an accurate representation of the real world artefact as possible. Adjustments consist of the ability to rotate and crop a photo, and adjust a combined brightness and contrast slider (similar to Instagram's 'Lux' setting) to fix lighting and exposure problems. Users are then encouraged to provide a caption and tags for the post. Users are also provided a means to adjust the geo-location of the post slightly (within 20m), to account for minor errors in auto geo-tagging. For example, when taking a photo of a billboard, it is often impossible to fit the billboard in shot when only a couple of meters away from it. In this example, this would result in incorrect geo-location data that would need fixing. Once the post is captioned and tagged, users may share this as a post.

4.3.2.3 News

The 'news feed' section has two screens (Figure 4-8). The first provides a constantly updating list of posts. The news feed is populated with posts based on a user's followed tags and users. The 'following' screen provides a personalised and customisable feed of everything a user may be interested in. The 'activity' screen provides an activity feed for actions performed by community members the user wants to be kept aware of. The actions shown in the activity screen can be changed via the app's setting to meet the preferences of individual users. The activity screen has the ability to show any interactions relating to posts the user has made, bookmarked, or interacted with.

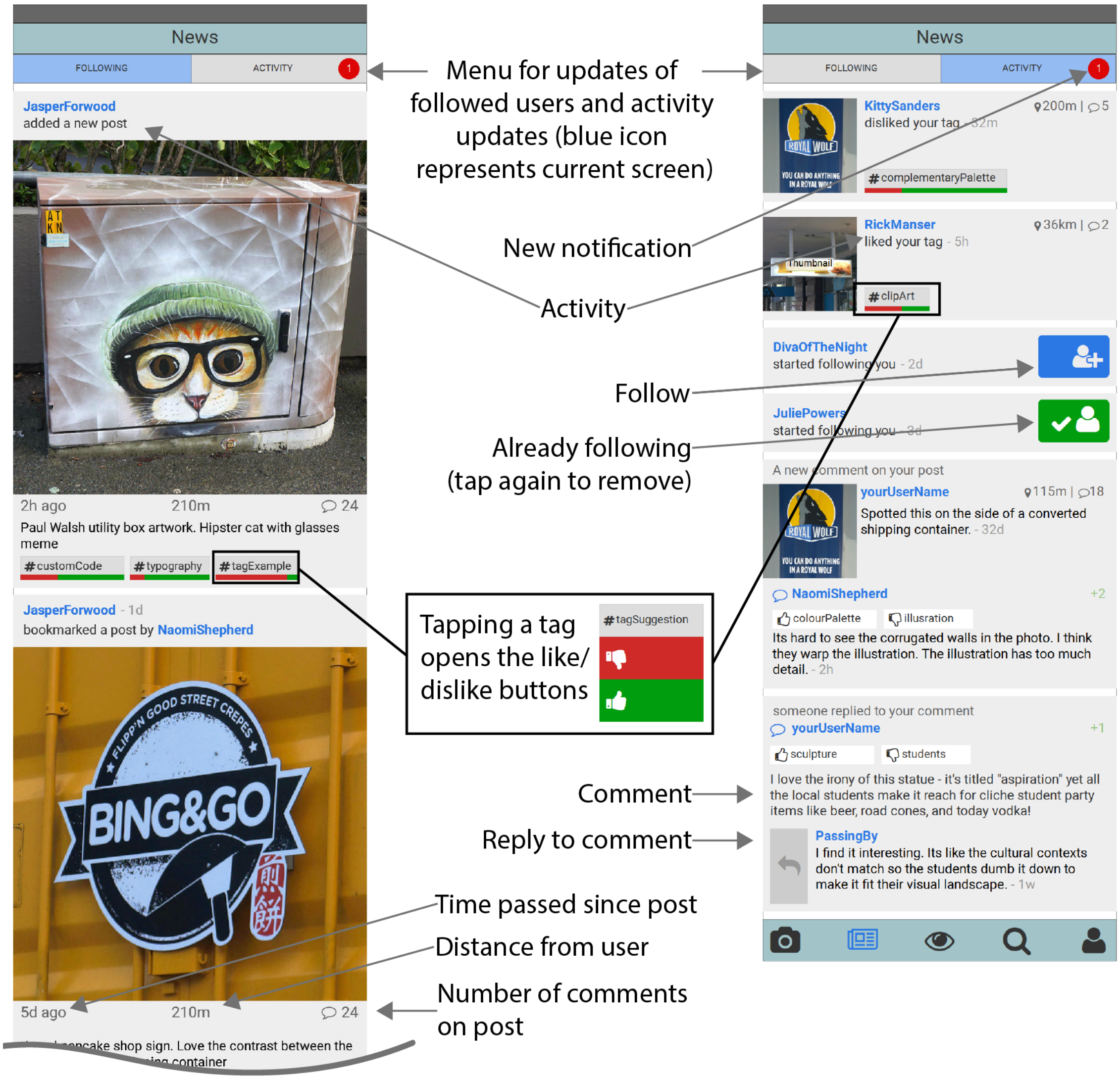


Figure 4-8: The "following" and "activity" screens found in the "news" section of the low-fidelity prototype. Author's original composition.

4.3.2.4 Search

The 'search' section of the app (Figure 4-9) provides the user with controls to find content or people.

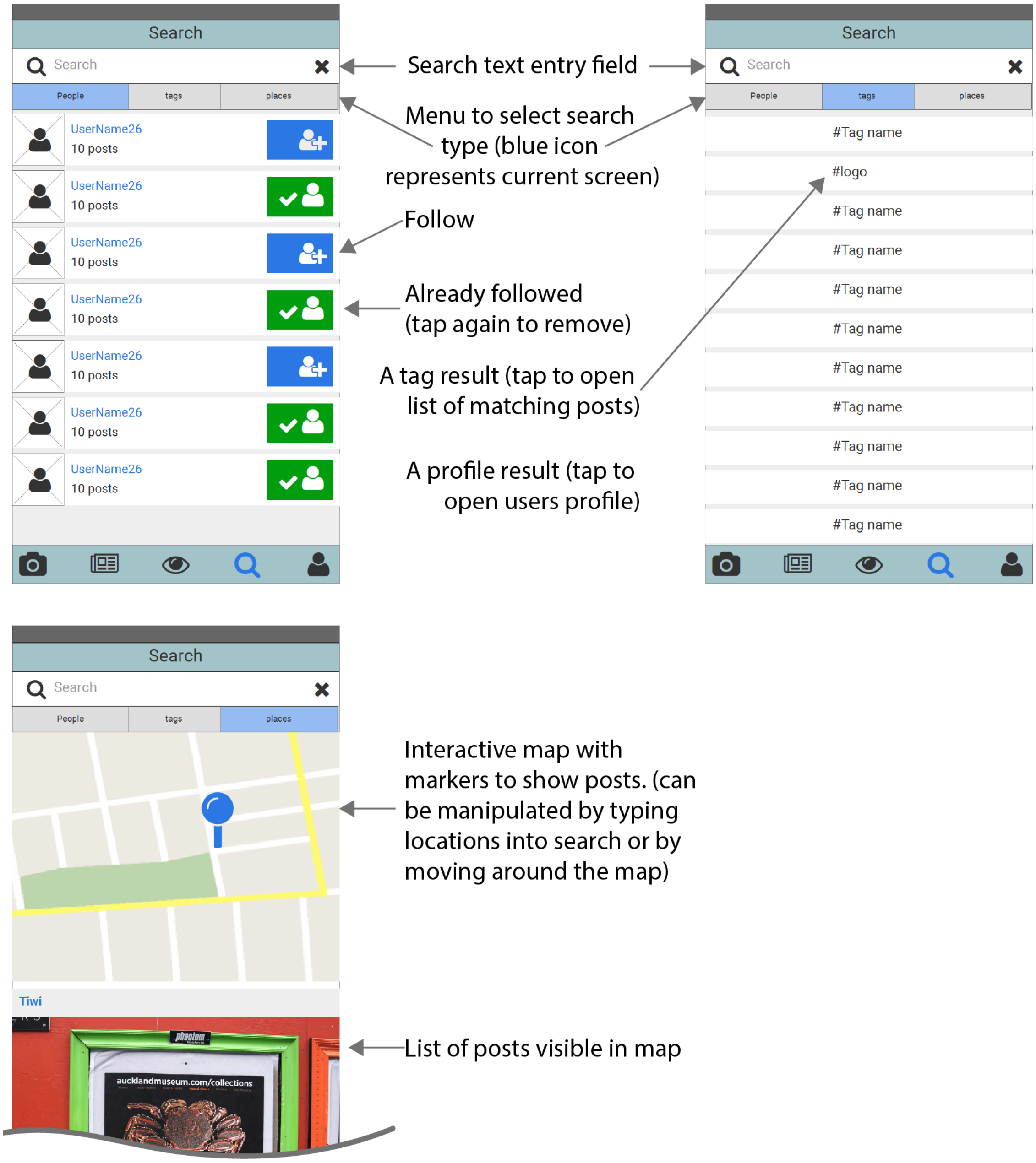


Figure 4-9: The 'search' section of the low-fidelity prototype, demonstrating the 'search people', 'search tags', and 'search places' screens. Author's original composition.

The first search screen, 'search people', provides a means to look up other users and either open their profiles, or follow them. The second search screen, 'search tags', provides a means of looking up posts based on their associated tags. Tapping on a tag name from this screen will produce a screen similar to the list screen (Figure 4-6), where posts are displayed relating to the tag searched for. The last search screen, 'search places' provides a means to search via location. A user may enter a location in the search bar, or navigate the map through swiping and pinching to move or zoom into the map displayed. The map contains posts marked as points of interest that will open associated posts when tapped on.

4.3.2.5 Profile and settings

Figure 4-10: The low fidelity prototypes's 'profile' section demonstrating the 'posts', 'comments', and 'bookmarked' screens. Author's original composition.

The 'profile' section (Figure 4-10) displays the activities of the user currently logged in to the app. Through a tabbed menu under the profile picture, a user can display all the posts they have made in the 'posts' screen, all the comments they have made in the 'comments' screen, and all the posts they have bookmarked in the 'bookmarked' screen. These screens use the same format as the 'following' screen in the 'news' section (Figure 4-8) to display and access posts. The same screen structure used to display a logged-in user's profile is used when viewing other users' profiles, with the exception of there being no 'settings' button present at the top centre of other users' profile screens. The settings button opens the apps preferences and settings for the currently logged in user.

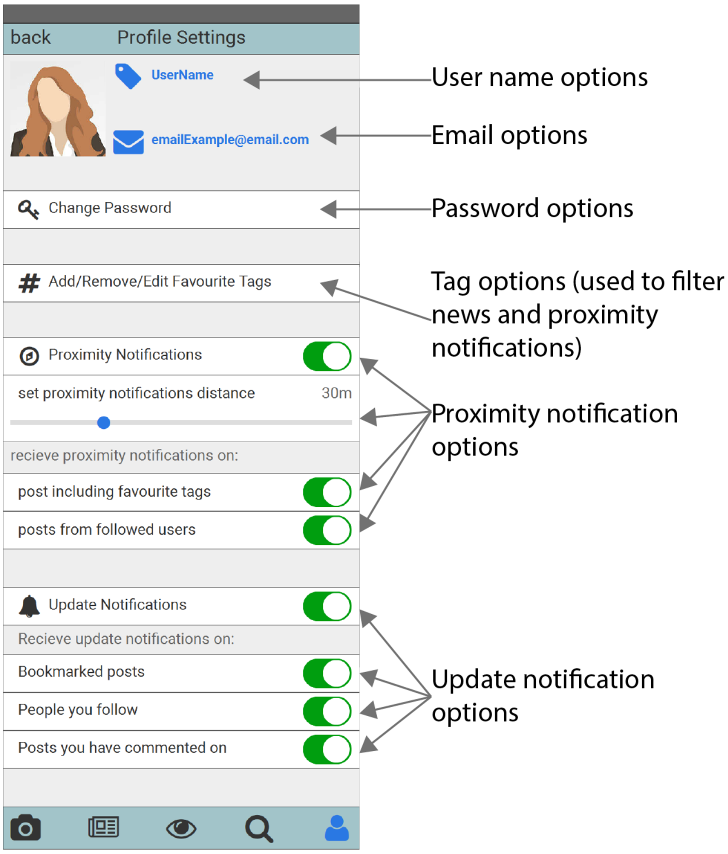


Figure 4-11: The 'settings' screen of the low-fideltiy prototype. Author's original composition.

The 'settings' screen (Figure 4-11) of the low fidelity prototype allows users to adjust settings and preferences. Users can change their name, email, password, followed tags, proximity notification settings, and update notification settings.

4.3.2.6 Push notifications

The prototype also includes mock push notifications (Figure 4-12). A push notification is a message that pops up on a smartphone from an app. Push notifications can be sent at any time and users do not have to be using the app or their device for the notification to be received. These represent an entry point into the prototype app that is intended to engage a user when they are not using the app. There are two types of push notifications. The first makes users aware of any activity on their account, such as a comment on their post or someone replying to their comment. The second is a proximity notification. As a user enters the proximity of a post that relates to a followed tag or user, they receive a push notification so they may experience a posted visual in person.

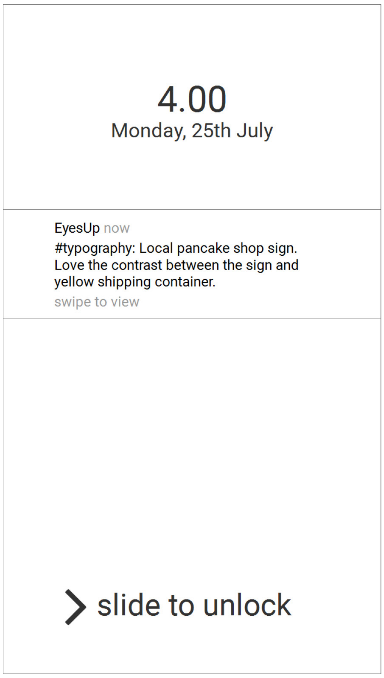


Figure 4-12: An example of a proximity push notification issued to a user's smartphone by the low-fidelity prototype. Author's original composition.

4.3.2.7 Onboarding

The onboarding screens are encountered when a user first launches the app and attempts to create an account. The first set of onboarding screens (Figure 4-13) follow a linear path to prompt a user to set a username, profile photo, suggest and choose tags to follow, suggest and choose users to follow, and turn on the apps notifications. These screens establish a user's initial preferences for the app.

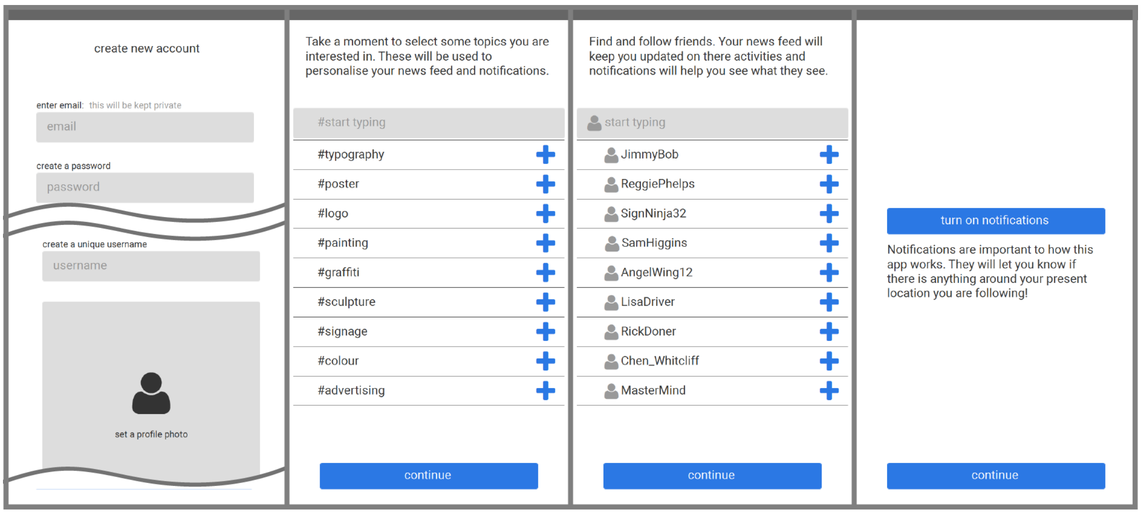


Figure 4-13: The low-fidelity prototype's first series of onboarding screens, in order of encounter from left to right. Author's original composition.

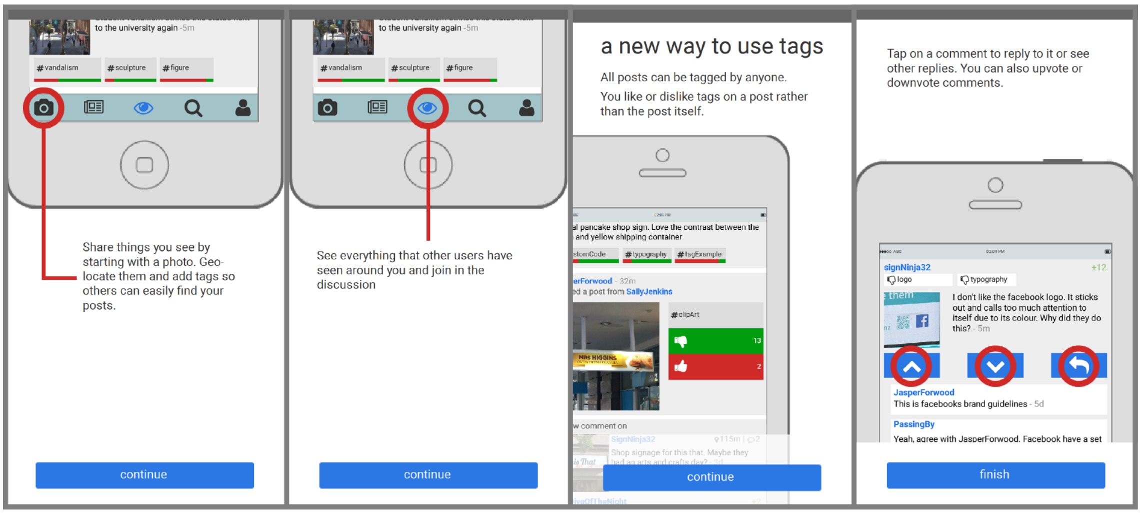


Figure 4-14: The low-fidelity prototype's second series of onboarding screens, in order of encounter from left to right. Author's original composition.

The second set of screens in the onboarding experience (Figure 4-14) aim to educate new users on how the app works by providing a guide to some of the apps features. The first screen in Figure 4.14 highlights the menu option for creating a post. The second screen in Figure 4.14 highlights the menu option for experiencing posts in the user's proximity. The third screen in Figure 4.14 explains how tags can be either liked/disliked. The fourth screen in Figure 4.14 demonstrates how to up-vote, down-vote, and reply to a comment.

4.3.3 Low-fidelity prototype experience

The low fidelity prototype was divided into two experiences for the usability testing sessions. The first represented an onboarding experience to replicate a user's first encounter with the app. The second represented the experience of opening the app having completed the onboarding experience in a prior session.

The onboarding experience can be viewed at the following link:

https://invis.io/V88Y80RY5

Having completed the onboarding experience in a prior session, the experience of opening the app can be viewed at the following link:

https://invis.io/P68Y812NY

4.4 Chapter Summary

This chapter reported the outcomes of phase one and two of the research design. Phase one produced a tentative learning model that operates on the overarching assumption that persistent access to support and collaboration with more capable peers is required for novice learners to learn visual literacy decoding skills. These are learned from visuals encountered in their everyday environment. This is supported by the nine pedagogical assumptions which describe how visual analysis may be used to learn in an informal, collaborative, decentralised, and ubiquitous manner. Phase two produced a low-fidelity prototype of an app that operates on the pedagogical assumptions of the tentative learning model. The app is a social media experience tailored specifically to visual learning by leveraging the visuals the app's users may encounter in their environment. With the tentative learning model and low-fidelity prototype understood, the following chapter, Chapter 5, reports the results of testing these two outcomes.

Chapter 5: Usability Testing Results

5.1 Introduction

In Chapter 3 of this thesis, a research design for usability testing was established for this study (see Section 3.6). The usability testing employed novice visual literacy learners to test the low-fidelity prototype by attempting representative scenarios of the apps intended use, and by answering questions relating to visual literacy and its learning. This chapter reports the results of this testing. The aim was to collect data that may be used to validate or refine the low-fidelity prototype and the tentative learning model. The reporting takes place in three sections that mirror the phases of the usability testing sessions, namely, the warmup, usability testing, and interview.

5.2 Warmup Results

The usability test sessions began by asking three open ended warm-up questions, each with follow-up questions to elicit more detailed explications from the participants when necessary. This part of the session occurred before they were introduced to the prototype app or concepts of the learning model. Responses were not biased therefore by their experience with the app or learning model, so that data collected may potentially be used to support or reject the premise for both the learning model and app.

5.2.1 Warmup question 1

Question one asked: *Tell me about your last experience learning the rules or ideas of visual communication—in particular, the ones that helped you read, interpret, or understand images you see?*

Four of the five participants answered the question with an experience from the visual communication course they were recruited from. P2 was the exception who answered with online learning. Participants were then asked: *What did you do to better understand these rules or ideas outside of class?* Followed by: *Was this helpful?* Four out of the five participants answered the question with using online resources, including YouTube, Lynda.com (an online video library of train resources), Google searches, and Wikipedia. These four participants all believed this helped their learning, and two participants noted that this also supported their learning in class as a means to cover missed content or delve deeper into the subject matter. The exception was P3 who answered that they used their physical environment to learn, stating:

> Once you start learning the theory and stuff behind it [visual communication], and you will look at images outside like billboards and stuff and think “oh, that's why they have created it that way.”

P3 stated that this was the result of undertaking a course in visual communication, which has made them more aware. P3 was then asked what they had learned from this practice, and said:

> I've learned the ulterior motives behind why things are created the way they are created.

5.2.2 Warmup question 2

Question two asked: *Can you tell me about a time you noticed an image (billboard, sign, poster, etc.) you may have passed on the street and gave some thought to?*

All the participants recounted an experience of an advertisement they had encountered, followed by their analysis of it. P1 explained this was due to their formal education, commenting:

> I think recently—because I want to major in advertising—I have been taking a lot more notice of billboards and stuff.

All the participants (except for P2), recounted an advert they had noticed themselves. P2 explained how, in a class setting, an image for a men’s skin care product was brought to their attention by a lecturer. P2 then shared what they remembered of the experience:

> There was a really cool advert, I think it was for Nivea Men’s Skin Care. It had a close up of a man’s forehead and it was quite wrinkled, but it was of a little girl holding on to the wrinkles. …I thought it was quite humorous and I realised that you can show not tell. That's what I learned. There’s a lot you can do with an image. There’s a lot you can imply…

Participants were then asked if they learned anything through the experience they described; their answers were split. P2 and P5 believed that they did learn, while the three other participants stated they did not learn, instead stating it was a means of practicing or appreciating visual communication. Participants were then asked if they thought they could learn by paying attention to visuals in their environment. All participants believed they could, however some answers were conditional. P2 noted that although they believed they could learn by examining visuals in their environment, they would like:

> A bit of description, or a little bit of analysis to go with it.

P3 commented:

> I guess if you were motivated to do that. If you wanted to put the effort in to do that then there's some type of reward at the end.

P4 and P5 both noted they could and did so presently. P4 commented:

> I think if you have a basic knowledge of it [visual communication] then you can come to understand how rules come into play and how professional techniques are used. Whereas, if you had no background, I think it would be harder to understand them. … I have been looking at them [visuals] and trying to not just interpret the message, but see what has gone into being able to make people want that food, or object, or thing that they're trying to sell or advertise.

P5 similarly expanded on their response of requiring basic knowledge:

> Yeah, I try to because I'm a Comms [Communications degree] student, and because I do graphic design. I definitely like to look at ads and billboards and where they can be improved—I think you can learn from that. And especially with things like logos—I like to look at logos, that teaches me.

5.2.3 Warmup question 3

Question three asked: *Can you tell me about any forums or communities where you learn visual literacy outside of class?*

P4 answered that they had not used any. Communities and forums mentioned by the other participants were all online communities or forums, namely; DeviantArt, Instagram, Lynda.com, Pinterest, Reddit, Tumblr, and YouTube.

Follow-up questions included asking what the forums, tools, or communities were used for, if the participant found them effective, and what they thought lead to their learning while using them. P2 commented:

> I think the reason why I like forums is because they normally have a lot of discussion, and I find it really interesting. Just hearing the different perspectives and people's opinions on how they interpret an image or subject, which may not necessarily be correct—it doesn't really matter— but you know it's quite interesting … then you can, I guess from seeing other people's opinions, form your own.

P1 and P5 believed their experiences with communities and forums were beneficial, but did not perceive them as learning. P4 believed forums and communities to be a means of gaining inspiration rather than learning, as communities and forums do not give 'how to's or 'guides' on specific techniques to execute in their own practice. P5 had similar thoughts and commented:

> DeviantArt, Tumblr, and Pinterest. I'm always on those sites looking at cool images, especially on Pinterest. There are all these interesting design related things—I have a whole board of design inspiration. But I don't formally learn rules [from Pinterest], it's more like seeing things that I like and thinking about how I could replicate them.

5.3 Scenario Results

The second part of the usability testing session constituted user testing of the low-fidelity prototype. Comments and actions relating to participants reception and their observed levels of engagement with the app are reported first in Section 5.3.1. This is followed by a summary of usability issues comprised of identified mistakes, hesitations, and pathway deviations for each scenario undertaken as well as any statements relating to the tentative learning model (Sections 5.3.2 – 5.3.10). As a key feature of the prototype, any issues regarding the commenting and tagging system throughout the scenarios are reported in isolation from the scenarios in Section 5.3.11. Lastly, desires for additional features as expressed by the participants throughout the usability testing session, are noted in Section 5.3.12.

5.3.1 Reception

After completing the nine scenarios (see Appendix D), P1, P3, P4, and P5 were asked their thoughts about the type of learning that would occur on the app they had just trialled (P2 was not asked due to time constraints, ending the session early). They were also asked how much they think they would learn using the final app. Responses were overwhelmingly positive.

When asked how they felt about the low-fidelity prototype app used in the usability testing session, P1 responded:

> Good, because it is enjoyable and it is social, and it makes learning less of a chore or less of a thing that you have to do, and more something you want to do. Like, say you're waiting for a friend in a cafe you could pull it out and scroll through. It's not something you have to sit down with a text book and dedicate a lot of time to, it's something you can do in your own time and it's enjoyable.

P1 also offered their thoughts on the learning style embodied by the app:

> I feel like my style of learning – I really struggle to focus, so I feel I would really thrive using this app because you can see things, but then say something else happens you put your phone away but you're still kind of processing what you saw. And that's how I learn, through processing rather than kind of just absorbing information from a text book.

P3 responded:

> This would have been cool while I was doing Vis Com [Visual Communication, a course in the participant's degree] to have this. I think this is just a lot more interactive … and I think people are already on their phone using social media like Facebook and Instagram so this is just another thing that can feed into that so it doesn't even really feel like learning. It's just like observing and being amused by stuff that's happening on the app.

P3 went on to state they had no intention of pursuing further learning in visual communication, as they were changing the focus of their studies. However, they still perceived value in the app as a source of entertainment. P3 noted the app should be considered for more purposes than just visual learning, and that it may have potential as a social media platform.

P4 responded:

> I really like it. It's cool and it's more stimulating and it makes you think more than just a mindless scroll of unnecessary stuff. … You could do this while watching TV or during an ad to kill time and you're still thinking and engaging with it [visual literacy] rather than just not really caring.

P5 responded:

> I think it's a really cool idea, and I think it would be something I used as well. Especially if I had to for a class, but probably I would keep using it after class had finished, especially if it had a good community. And I feel you could learn a lot, because you might miss … some cool artwork or sculptures you never noticed. Especially living in the city, it's interesting just noticing all these different things around you. And it's cool, for example, say I don't know much about sculpture or like fine art, but I could actually read [from] people who do know a lot about it and actually learn something rather than just look at it and be like, oh that's cool. I think it's a neat idea. How do I feel about the learning? Yeah, I feel good.

Without being prompted, P3, P4, and P5 commented that they would like to download and use the app if it were available. Although P2 was not directly asked their thoughts on the prototype, they commented during the session that they would prefer to learn using something like the app if they had a choice on how to best learn about visuals.

One point of caution was raised by two participants who briefly mentioned that the value of the app is in the quality of the community. For example, when asked how they felt about the learning that would occur on the app, P3 said:

> I guess it depends on the users that are on the app.

All the participants (except for P2 due to time restrictions) were asked how often they would engage with the app and for how long each time. Answers varied widely and appeared dependent on notifications, the quality of the community, and the participant's field of study. All the participants said they would engage daily with the app. However, the participants also answered conditionally. Participants P3, P4, and P5 answered that their engagement would be conditional on how the notifications work. Participants believed there was an ideal medium; not too many so they would ignore them or turn them off, and not so few as to not engage sufficiently with the app. P1 believed their engagement would be conditional, based on their studies. They rationalised that if they were actively studying visual literacy or related fields in a formal setting, they would likely engage with the app more.

Responses to time spent with the app varied widely too. P1 likened the experience to browsing Pinterest, where they could spend two to three hours a session browsing content. Other participants said their time spent could be brief but frequent interactions of a few seconds per interaction in response to notifications that highlighted real world examples. One participant said these brief but frequent interactions could be up to twenty times a day.

5.3.2 Scenario 1

	Scenario	P1	P2	P3	P4	P5
1	Your visual communication lecturer has just told you about a new app that may help you practice what you are learning in class. The app is called EyesUp and your lecturer suggests you check it out. Can you please open the app and create a new account?	✓	✓	✓	✓	✓

Table 5-1: Scenario 1 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

The purpose of scenario 1 was to replicate how users would first encounter the app and come to understand it. The scenario was also used to introduce participants to the limitations of the prototype which included its wireframe nature and rudimentary interactivity.

All participants stated that they understood the introduction screens and the purpose of the app by explaining it back to the interviewer. They believed they understood enough after onboarding to explore the app comfortably. One participant was observed to race through the onboarding process, quickly tapping the continue button.

Participants offered thoughts on improving the experience. One participant felt that the onscreen text needed to be larger throughout the onboarding screens. P3 suggested that there should be a sign-in process based on other social media accounts.

General comments throughout the onboarding process showed that participants liked the idea of following friends. For example, P3 commented:

> I think if you find your friends then you're more likely to interact with the app and play along with it and with them.

5.3.3 Scenario 2

	Scenario	P1	P2	P3	P4	P5
2a	You are waiting for a friend in a café who is running 10 minutes late. You decide to check the app (EyesUp) to see if there is anything around you. Open the app and check if there are any posts close to you using the AR, List, and Map view.	✓	✓	✓	✓	✓
2b	You decide to check out one of the items that are around you and both up-vote and reply to a comment.	✓	✓	✓	✗	✗

Table 5-2: Scenario 2 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

Scenario 2 had two parts. The first part was designed to reinforce the purpose of the app and introduce how the app would work. The relevant screens in this scenario are the first ones a user would encounter following onboarding or re-launching the app from a previous session. Participants were asked which view out of ‘map’, ‘list’, and ‘see’ they found the most useful (Figure 4-1) and all responded with the ‘list’ view. Participants thought the combination of text and images presented information in the easiest to digest format. Participants were then asked if they would use all views together or just stick to the ‘list’ view, to which all stated they would use all views. Three participants noted the ‘see’ view as useful for spatially orientating one’s self to real world examples, and for being fun and engaging. For example, P4 commented, “I really like the whole like augmented reality [see view], so you can see where things are around you”, and P5 likened the experience to playing Pokémon Go. P2, P4, and P5 also noted the map as useful. P2 particularly liked the idea of how a map’s birds-eye view displayed an environment in a different perspective from what they would normally experience through their normal process of physically moving through their environment. P5 commented that they believed the map view would be most useful, as they could see all posts presently in their surroundings, and would use it before making any posts to check if someone else had already posted something they had noticed. The participants also commented that they liked the idea of being able to browse maps to see what is occurring in other locations, and that they did not have to be physically present to view visuals others may have added to the learning community. P5 believed the ‘map’ view could be improved by including the bookmark status of each post that appears within it, so a user would know if they had viewed or saved a post in earlier sessions.

Figure 5-1: The 'map', 'see', and 'list' views. Author's original composition.

The second part of the scenario required each participant to open a post from the 'map', 'list', or 'see' views, and then up-vote and reply to a comment on the post. Two of the five participants struggled with this task. The first usability issue occurred as a participant took a long time to discover they needed to tap on a comment to open the options for replying and up-voting (Figure 5-2). The second issue resulted when a participant mistook the tag 'like' and 'dislike' status associated with each comment as the buttons to up-vote and down-vote (Figure 5-3). This problem was compounded by having the up-vote and down-vote buttons hidden until the comment was expanded, whereas the thumbs-up and thumbs-down of the like and dislike status of tags are always visible (Figure 5-2).

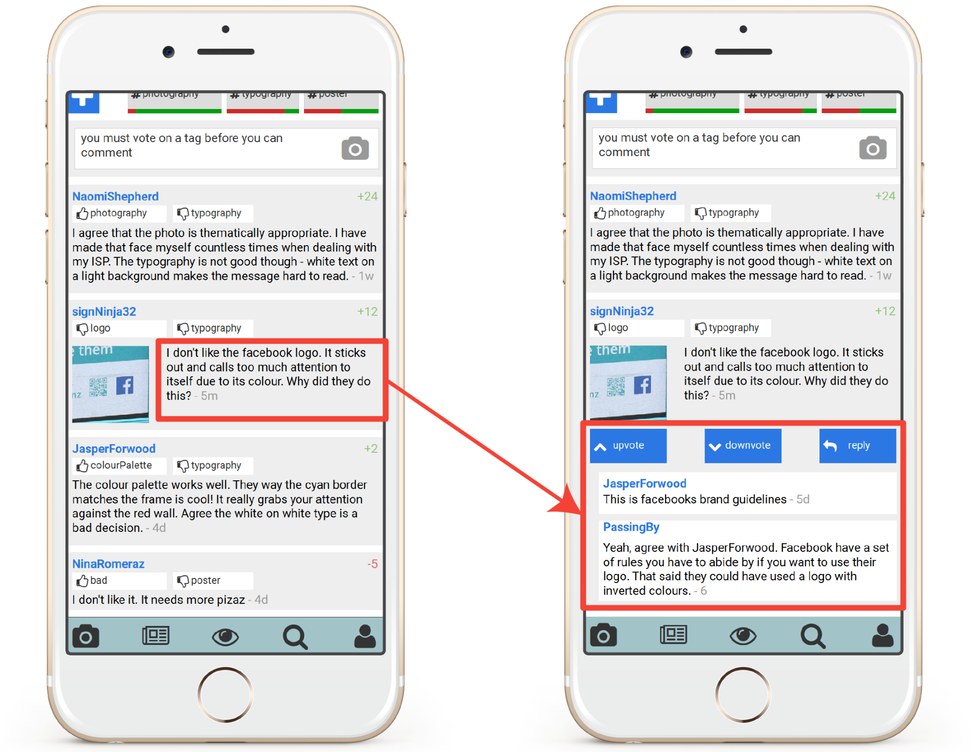


Figure 5-2: The need to tap on a comment to expand it and access options to reply, up-vote, down-vote, and comment caused confusion. Author's original composition.

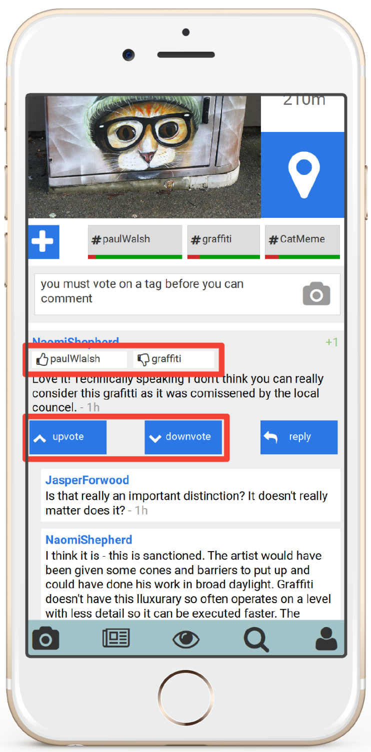


Figure 5-3: The like and dislike status of a comment (top red box) for the up-vote and down-vote buttons (lower red box) caused confusion. Author's original composition.

5.3.4 Scenario 3

#	Scenario	P1	P2	P3	P4	P5
3	You are walking down the street on the way to university. Your phone beeps to let you know you have a notification. Check it out and vote on one of the items associated tags.	✓	✓	✓	✓	✓

Table 5-3: Scenario 3 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

Scenario 3 sought to test how push notifications may be used to alert users to posts in their immediate proximity. One participant hesitated for a few seconds before attempting to tap on a tag to like or dislike it. Each participant was asked if they would add a tag to the post, followed by what they would like included. Participants responded that they would add the tags ‘photography’, ‘poster’, ‘concept’, ‘advertising’, and ‘confused white man’ (jokingly).

5.3.5 Scenario 4

#	Scenario	P1	P2	P3	P4	P5
4	You are taking a new class and your lecturer tells you about layout grids. You decide to follow that tag as a way of seeing grids in action.	✓	✗	✓	✗	✓

Table 5-4: Scenario 4 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

Scenario 4 involved the most complex navigation in the test. Participants had to navigate to their profile, then settings menu, then the specific option for following tags. The two participants who encountered difficulties first went to the search page to search for tags. Once they had conducted a search, they looked for a way to follow the tags in the search results (Figure 4-4). Upon realising this would not work, both participants proceeded to check every page until eventually locating the settings. One of the successful participants commented that they would probably go to the search page first to look up which tags were available to follow, demonstrating similar thinking to the participants who had difficulty navigating the app.

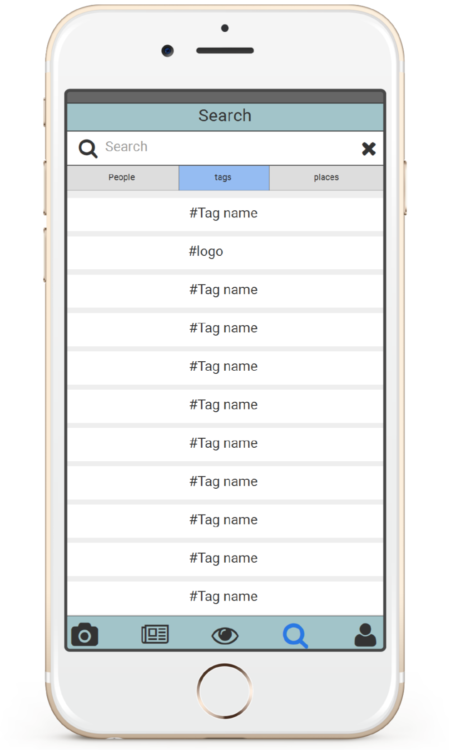


Figure 5-4: The search results page caused confusion as participants expected an option to follow tags from here. Author's original composition.

P2 identified a usability problem with the use of a tag icon on the profile page next to the username registered on the app (Figure 5-5). The intention of including the tag icons was to act as a name tag icon, signalling to the user that the text following was their set username. However, P2 found this misleading as they were looking for tag options, mistaking the icon for a button relating to the tags system used within the app.

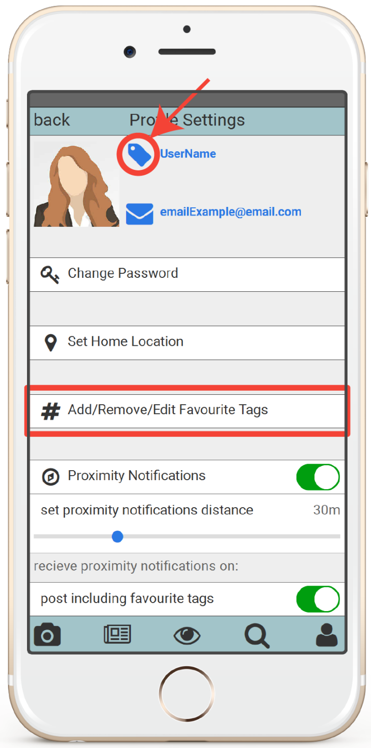


Figure 5-5: The red arrow points to the tag icon that was confused for the follow tag options highlighted by the red box. Author's original composition.

5.3.6 Scenario 5

#	Scenario	P1	P2	P3	P4	P5
5	You are walking past a food stall and notice it has some interesting signage you want to share on EyesUp. You are not too sure what that style would be called. Create a new post of this on EyesUp. For all the entry fields, please state aloud what you would enter.	✔	✔	✔	✔	✔

Table 5-5: Scenario 5 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

While the posting process involves many steps, users are bound to a linear path leaving little room for errors. Follow-up questions to scenario 5 revealed, however, aspects that required further consideration. For example, upon sharing a post, a user is redirected to their profile which displays a feed of all the posts the user has made; the post they have just made appears at the top. Two participants commented that they would have expected to be redirected to the news feed with the post just created at the top of that feed.

Participants were asked if they wanted any prompts or other additional features throughout the posting process. P3 commented that they would like the ability to post photos they had taken earlier, and that they would also like the option to share to other social media networks. P4 expressed a desire for photo filters to alter photos after they were taken.

The scenario prompt included, ‘You are not too sure what that style would be called’, to see how participants would deal with unknown visuals. The participants all sought community help by asking for clarification through making comments or by using tags. Following the scenario, participants were asked if they would seek help from a community such as that found in the prototype app to aid in their own visual analysis. Everyone answered yes, with P1, P2, and P3 adding they would ask specifically for other’s opinions as the means of receiving help. Additionally, P5 noted that providing help as a community member may be a motivational force to engage with the community:

> And if you’re really good with your critiques, and people keep up-voting you, it might encourage you to comment more and help out other people.

P3 perceived a potential problem with the geo-tagging feature of a post, as this would reveal their location upon posting. P3 commented:

> There might be people who like the app but might not want to be actively sharing where they are all the time. So, they would obviously more favour being in one place and then uploading it from there, rather than being in that same place they are uploading from.

5.3.7 Scenario 6

#	Scenario	P1	P2	P3	P4	P5
6	The EyesUp app has a notification badge above its home screen icon to let you know there has been activity on your account. You checked the app an hour ago, so the notification must be recent. Open the app and see if there was any activity in the last hour that could account for the badge.	✔	✔	✔	✔	✘

Table 5-6: Scenario 6 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

Scenario 6 was completed quickly and easily by all but one participant, who checked their profile first before correcting themselves and opening the news feed to find the post flagged by the notification. The participant commented the notification badge should appear on the news feed icon in the main menu so it may be seen from all the main screens within the app (Figure 4-6).

As a follow-up to scenario 6, participants were asked to browse the news feed and activity log and raise any concerns they had with these. Participants raised issues regarding comments and their replies to those comments. The first was that the comments on the activity feed are confusing, as they included both the original response and the reply (Figure 4-6). The second was that the structure would be clearer if only the responses to posts were visible. The third suggestion was that the news feed had too much text and should have more focus on imagery.

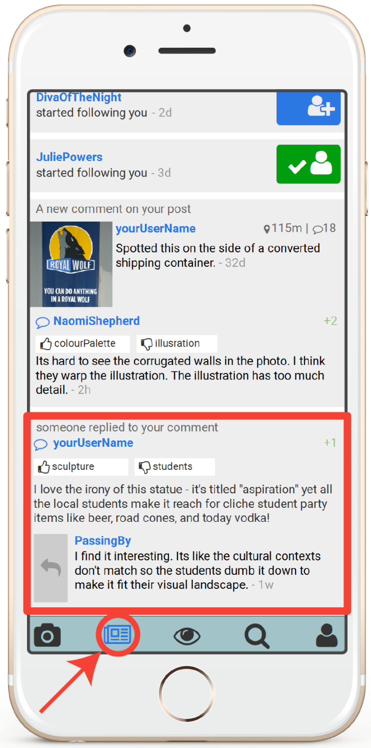


Figure 5-6: The arrow points to where participants wanted a notification badge to appear, while the red box highlights the reply to comment structure the participants found confusing. Author's original composition.

5.3.8 Scenario 7

#	Scenario	P1	P2	P3	P4	P5
7	A friend is telling you about a sign they saw on Rutland St just off Queen St. Search the location and see if you can find this sign on the app EyesUp.	✓	✓	✓	✓	✓

Table 5-7: Scenario 7 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

Three participants answered the scenario by using the search page, while the other two participants opened the map view to navigate to the sign.

P2 revealed a potential problem with the use of tabs on the search page under the text entry field. As P2 attempted to tap on the search box, they accidentally tapped the tab beneath it. They recognised their mistake immediately and corrected it. The participant felt the interface elements were too close together. The elements have no gutter between them leaving no margin for error when tapping one option or the other (Figure 4-7).

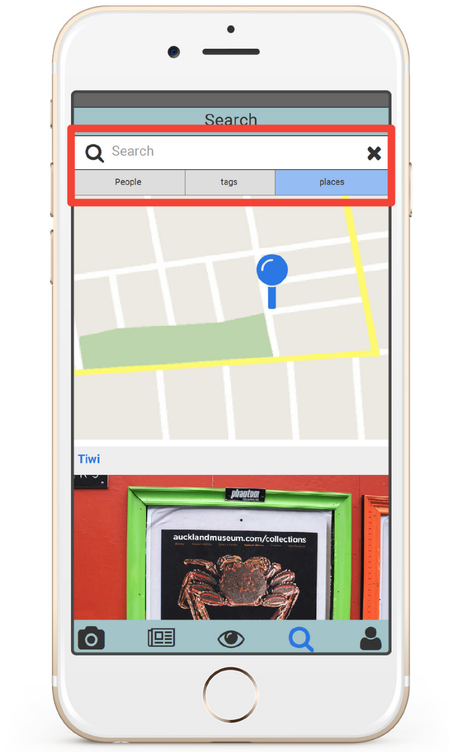


Figure 5-7: Red box highlights a potential problem with four interface elements that are too close together. Author's original composition.

5.3.9 Scenario 8

#	Scenario	P1	P2	P3	P4	P5
8	You are watching TV and the ads come on. You pull out your smartphone and decide to see what's happening on EyesUp by checking out the latest posts and comments. Open an item from the news feed and bookmark it for later.	✔	✔	✔	✔	✔
8b	Navigate to your bookmarks and see what you have bookmarked.	✘	✔	✔	✔	✔

Table 5-8: Scenario 8 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

The participants completed the primary scenario of bookmarking a post with ease. One participant looked for a way to bookmark from the news feed itself, but then opened the post and bookmarked from there when they realised this was not possible.

The follow-up task of locating where the bookmarks are saved presented a problem for P1. They navigated to the map view expecting to see all bookmarked posts indicated on the map. The participant expressed a desire to use the map as a filtering mechanism for the bookmarks, locating previously bookmarked posts via location rather than in a chronological list format. P5 also desired filtering options for bookmarked items, commenting that filtering by tag would be useful.

5.3.10 Scenario 9

	Scenario	P1	P2	P3	P4	P5
9	You disagreed with a comment a week ago and want to show it to your friend. Try to find a reply to a comment your account has made.	✔	✘	✔	✔	✔

Table 5-9: Scenario 9 results summary. A red cross indicates that usability issues were encountered, while a green tick indicates the scenario was completed without incident by a participant.

Four participants completed the scenario quickly and easily. P2 was the exception, who first looked for a reply comment under the news feed, believing the news feed would operate in a manner like Facebook's activity feed. However, they were then able to correct their actions and navigate to the profile page to complete the scenario.

5.3.11 Commenting and tagging

Throughout the user testing session, participants were asked to comment on posts they had seen, and to like and dislike tags they were encountering. This happened randomly, with some trying to comment as early as the second scenario, while others attempted it much later in the session (after most of the scenarios were completed). To comment on a post, the app first required one to like or dislike a tag (Figure 4-8). This process caused the most confusion in the usability testing sessions. Thus, follow-up questions were asked to collect the participant's thoughts on the tagging system and needing to like or dislike a tag before commenting.

Two Participants, P2 and P4, had no difficulty with the process, commenting quickly and easily. Two participants, P1 and P5, commented with some hesitation. These participants needed to stop and consider the tags before proceeding with commenting. P3 initially had some problems as they attempted to comment during scenario 2, having only just encountered the feature to do so, while other participants tried later in the process. Thus, P3 was unsure about liking or disliking tags before being able to make a comment. As P3 became more familiar with the app, they were asked if they could now comment and completed the process conceptually with success.

Two participants commented on usability issues. P5 said:

> I don't know, that's just a bit counterintuitive to click this first [the tags] rather than that [the comment box]. But I guess once you know it would become second nature, but since I have never used it before I just went for that [the comment box].

P4 echoed the issue when asked about tagging before commenting by saying:

> I've never had to do that before on something. Usually you can just comment without having to be affected by that. … But I guess it's really cool and it hasn't been done before to my knowledge. But at the same time, it is really interesting that you have to do that.

P5 offered a potential solution to the problem:

> Or maybe this [the comment box] shouldn't even show up. You should click one of these first [referring to the tags] and then vote [like or dislike a tag], and then this [the comment box] slides down and you can write your comment. Because it does make sense, because you should tag it before you comment.

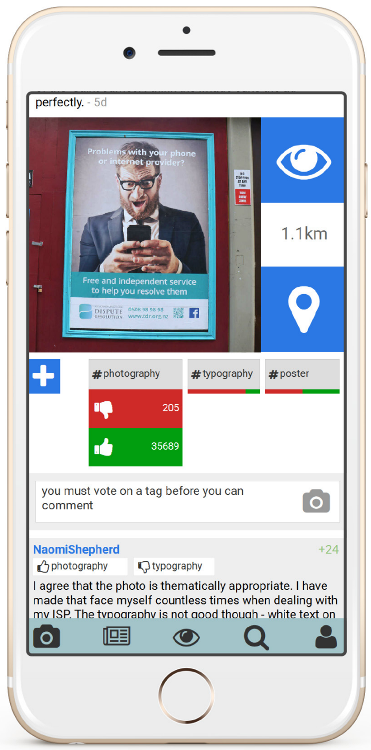


Figure 5-8: Tag with expanded like and dislike option visible with comment box underneath. Author's original composition.

Although some participants had difficulties with the process of commenting, all the participants liked the idea of having to like or dislike a tag before commenting and having that status visible. P1 was asked if the liking and disliking of tags should be removed as a prerequisite for commenting. P1 responded that they liked the idea of tags associated with comments and that it should not be removed, as it allowed comments to focus on specific aspects of visuals. P3 felt the same, noting the benefit of how you can gauge a person's opinion on a visual before reading their comment. P2 simply stated they thought it was "quite cool" while proceeding to engage with the app. P4 valued how they could see the majority view and whether their opinion was in the majority or minority. P5 engaged with the process by offering their own tags, likes, and comments.

Despite preferring to keep the idea of tagging before commenting, P1, P2, and P4 voiced concerns. P1 felt there should be a neutral option, arguing that they may not always have a strong opinion to share but still desire to comment or add in some way to a post. P2 felt people may not use the system correctly:

> But I hope it doesn't mean you just get random tags or random up-votes [likes] just because people don't know what to do.

P4 saw the visible like or dislike status of tags as a double-edged sword that may encourage people to comment if their opinion aligns with the majority while discouraging those who align with the minority.

Participants also perceived the system as a means of tailoring community content to their own preference. P2, for example, wanted the tag system as a means of filtering content, so the app would deliver:

> Only what you’re interested in, and not random other things that you don't really want.

Some participants said they had used tags on other social media platforms as filters already. P4, for example, commented:

> I personally don't tag things myself, but I find it really useful when people have used hashtags so that when I am searching for something I can find what I am looking for quickly.

Two participants also wanted a specific tag for visuals that are outliers, so that they may follow or filter posts by this tag to see what P3 referred to as “controversial”, and P4 referred to as “extreme or outrageous” visuals.

Participants were asked their thoughts on a notification that stated that one of their tags had been disliked. Two participants understood this to be a critique of the work they had posted, not perceiving the ‘dislike’ as relating to them personally. For example, P1 said:

> I wouldn’t take it personally because it wouldn't be my thing she's disliking, it would be someone else's design.

Two understood this as a critique of their work, but felt this critique was beneficial. For example, P5 said:

> It's more of like a critique session rather than a social media ‘haha’ [haha is said] everyone is happy all the time.

While one participant thought they may take dislikes personally.

Participants were asked what they thought the purpose of commenting was within the app. Responses among the participants were similar, with participants believing it would create a discussion, as analysis is shared and expanded upon through commenting, and this discussion would create engagement or be fun. P5 explained:

> It's like almost having a conversation. Like if you were sitting around with a bunch of designers or artists, you would be like, “that's good or that’s really shit”. So, it’s kind of fun in that sense because you can be opinionated.

Some participants found bad examples of visual communication the most appealing to analyse, for example, P5 commented:

> If it's terrible then you can rip into it—because I love doing that. Whenever I see a bad billboard, I'm like “what the hell does that even mean?!” [Laughs].

5.3.12 Supplemental features

Throughout the use of the prototype, participants were asked if they would like any other features; this lead to valuable insights. This sub-section summarises the miscellaneous comments around desired features, providing a list of supplementary features:

Participants expressed a desire for proximity radius features, particularly control over the radius for the list view.

Two participants mentioned they wanted the ability to change their usernames after creating an account.

Participants wanted the app to be able to integrate with other social media platforms. This included wanting to login using another social media account such as a Google account or Facebook, and then use the details of these accounts to find friends. Some participants desired the ability to share a post to several social media networks when sharing on EyesUp. They also wanted this integration to flow in the opposite direction, with the ability to use images from other social media platforms on EyesUp.

Some participants wanted the ability to add a biography to their account. One participant mentioned this would allow them to identify themselves as a student, practitioner, or educator for others to see. They rationalised this same feature could be used to see the status of other community members.

Some participants desired a featured person or special mentions area could be integrated into the app. P2 gave an example of wanting posts by Stephan Fry (a comedian and actor) to be featured, believing this would be entertaining. Another participant thought the app could have some special mention for exhibitions or events close to one’s location as a means of staying informed.

5.4 Interview Results

The interview component consisted of seven questions. The questions were designed to elicit experiences and thoughts relevant to the tentative learning model’s pedagogical assumptions and their application in the low-fidelity prototype. Each question included a series of follow-up prompts to draw more detailed explications from participants when necessary.

5.4.1 Interview question 1

The first set of interview questions probed the participants' views relating to learning communities. Participants were asked, *do you think it would be beneficial to learn or practice visual literacy skills in a community of learners such as those the app would use?* They all believed it would be beneficial, perceiving community settings as fun, interactive, entertaining, and engaging. P4 noted it would be especially useful in aiding their studies.

Participants were then asked how they would view information provided by others on the community. All participants stated that they would be receptive to different understandings or perspectives of visual literacy provided by the community on the app. For example, P1 said:

> I would view it [information provided by the community] positively because I think there is not one way of seeing things. The way I look at something, and the way I see something, and what I think about it is going to be completely different to what someone else sees. It would be really interesting to see what [other] people see.

Both P2 and P5 answered similarly and added that they are receptive to different views as long as the critics "back up what they say". P3 and P5 also stated they would not entirely trust community information, taking it with a "grain of salt".

Participants were then asked if they would share their own ideas on such communities, to which all the participants stated they would. However, P4 and P5 answered conditionally, commenting that they would have to feel passionately about an idea to share it. For example, P5 said:

> I am not too sure how much I would post on my own, unless I really, really, liked something or really, really, disliked something.

P4 also commented that they would have to feel comfortable to share their ideas within a community setting. They commented that if their idea was part of a majority held view, they would have no problem sharing. P4 also said if their ideas were controversial, they would feel more comfortable to share ideas if the community was comprised of family and friends.

Participants were asked if they would seek out sub-communities or organise their own. None of the participants wanted to organise their own sub-communities, but all liked the idea of participating in existing sub-communities, perceiving them as a means to pursue some specific aspect of visual communication related to their own interests or goals.

5.4.2 Interview question 2

The second set of interview questions probed participants' perceptions on whether they would contribute to the learning community. Participants were asked if they would share visuals with the learning community they had seen. All the participants answered yes. Although P3 answered yes, this was conditional on whether the visual was an 'extremity' of either good or bad visual communication:

> If it [an example of visual communication] was really, really bad then you would want to post that and if it's really, really good then you would want to post that.

Participants were then asked if they would give their opinion or analysis of others' posted images, for example, comment, like, or vote. P1, P2, P3, and P4 answered yes, and P5 said yes but only if they felt strongly about it. Participants were then asked the frequency with which they would expect to do this; answers ranged between one to eight times a month. However, P2, P3, and P4 were unsure, claiming they would need to see the quality of content produced by the community before deciding how much they would participate. P5 also believed their commuting routine would be a factor in how often they commented:

> I wouldn't be doing it every single day probably, just because I go the same route to and from home for the most part.

Participants were asked how they could be encouraged to comment, like, or vote more, both with the app or some other way. P1 believed that if their friends participated they would be more likely to use the app also. P3 had similar thoughts, commenting that if it "became a really big thing" then they would be inclined to also engage with it. P2 believed more utilisation of the augmented reality view they trialled in the low-fidelity prototype would motivate them to engage with posts. P4 and P5 both cited the 'like' and 'follow' mechanics as motivators to contribute more. For example, P4 commented:

> If I have a good following count then I would definitely want to either maintain or increase that. I would keep looking and I would probably have more incentive to go out and search for more [examples of visual communication] and post more.

5.4.3 Interview question 3

The third set of interview questions were related to the idea of visual analysis as a learning means. Participants were asked, *do you learn when analysing images?* And then, if they would share their analysis with a learning community. All answered yes to both questions. P3 explained:

> Yeah, because when you break it down you can apply the theory you have learned to it.

P4 also expanded on their answer to explain that they found the practice of analysis fun.

Participants were then asked if they would comment on other community members' shared analysis. All responded with a brief confirmation. This was followed by the question, *would you comment in disagreement?* To which answers varied greatly. P1 answered with a firm "no", believing peoples' analyses are subjective and deserve respect. P2 answered yes, but not in a "harsh disagreement" and would "backup why" they thought otherwise. P5 claimed they would only share ideas in disagreement, defending this stance by stating that, "if they've nailed it you would just agree with them and move on".

The last follow-up question to this section asked if participants would seek help from the community to aid their analysis of a visual. The participants all answered yes. P1 commented:

> I'd probably ask about potential meanings. Like what does this mean, or I don't understand it.

5.4.4 Interview question 4

The fourth set of interview questions were related to learners' preferences regarding social factors and collaborative learning. Questioning began by asking, *if you were learning visual literacy skills from your environment in a collaborative setting (such as with the app), what kind of activities would you like to be notified about in regard to other learners'/users' actions or activities?* Everyone wanted to be alerted to events happening within the learning community but had different preferences on what they would want to be alerted to. Three participants wanted to receive notifications of the activities of people they follow, including popular users of the app ('celebrities' specific to the learning community) and friends. For example, P4 answered, "I would want to see what my friends are doing [and] popular people on the app around me". P2 and P5 wanted notifications regarding activity on their posts, such if someone replied to a comment they had made or commented on one of their posts. Three participants were interested in receiving notifications based on location. For example, P1 said, "People who are posting things in my area, because I love to know what's going on around me". P1 continued to muse on the idea of location notifications:

> Travelling, that would be awesome, like you go to a new city and you pull out this app and you can see all this art around you and whatever. Like, I went to Melbourne a few years ago and there's so much cool street art and stuff, but it's a matter of finding it and knowing where it is, and I feel this app would be great for that.

P3 said they wanted to follow or receive notifications on a location, such as "my hometown or something – it would be funny to follow that. Like a home base type thing, and follow that stuff that would be from there". P4 spoke of the use of locational information to delimit posts, commenting that they would not want to see posts outside of their geographical location. The idea of limiting notifications, while not specifically asked by the interviewer, was also mentioned by P2, P3, and P5. P2 wanted specific settings for not receiving notifications, P3 wanted a separate ‘follow’ and ‘best friends’ feature that allowed for different levels of notification, and P5 wanted settings to limit notifications, and commented that they could see notifications becoming a “bit much” if they were to receive them on all activity relating to their posts, comments, and replies. P3 warned that not receiving too many notifications is important as “you would just turn notifications off, and then you wouldn’t interact with the app as much as you could”.

Participants were asked how they would like to receive notifications and how many. The participants wanted to receive notifications as push notifications, in app notifications, and badges. The desired amount of notifications ranged from no more than one every couple of hours, up to twenty a day. P1 warned “not too many or I would start to get a little bit pissed off”.

5.4.5 Interview question 5

The fifth set of interview questions related to highlighting and learning from one’s environment. Participants were asked, *do you think your visual literacy skills would benefit from having images pointed out to you as you go about your day?* All the participants believed their visual literacy skills would benefit from having images pointed out to them as they go about their day. P1 explained:

> Because it makes you stop and think about them [visuals]. You can get so caught up in doing things—running errands and completing tasks—that you miss visual things. It’s a good reminder to stop and appreciate them.

Participants were asked if they would stop and look at highlighted visuals and all said they would. Participants were queried how long they would expect to look at them. The responses were all for short time periods, with participants expecting to dedicate a few seconds to a minute on each highlighted visual. P1 commented: “It’s really dependent on my schedule. If I have more time I will spend a while looking at it [a visual], but if I am rushing somewhere it’s quick”, indicating time spent is dependent on the participant’s circumstances at any given moment. P4 felt time spent would depend on how many times they had encountered the visual, explaining that they might spend more time with first encounters, but then much less with visuals they have encountered previously. P5 believed that the time they spent would depend on what it was they are looking at: “A billboard, maybe just like a few seconds. But if it's like a sculpture or art piece, I might look at it a bit longer, like 30 seconds”.

Participants were asked about the frequency of highlighting. Participants’ responses varied from wanting visuals to be highlighted once a week to ten times a day. Two participants’ answers were tentative depending on circumstances. For example, P2 commented that the frequency of desired highlights would depend on the quality of the comments that accompany the visuals. In this case, the quality of the community, rather than the visual itself, was more important to P2. P4 said highlighting frequency should depend on their environment. "If you're in the centre of the city, then you would get more [visuals highlighted] than sitting at home when there is nothing around you."

Four of the five participants were asked if they felt highlighting images in their environment would be intrusive. Three of these four answered no, while P2 thought in some settings, such as an art gallery, it may become excessive if every artwork were to be highlighted. P4 envisaged highlighting as ignorable, commenting that, "you can always choose not to look at it, or just look at it and be like 'whatever'". The one participant who was not asked had already commented that they were unsure of how intrusive any kind of notification would be, but if in the case that they were, they would turn their mobile data off to prevent notifications such as highlighting.

Participants were questioned what contextual information they would like provided with the highlighting. P2, P3, and P5 all responded that they would like the history of each visual they encounter within the app. For example, P5 said, "If it has history behind it, or was created for a specific event, then that would be useful, especially if it's a statue or landmark." P1 began to respond to this question similarly, but then modified their response against this idea:

> I guess just people's analysis, or even information on why the art was created and a bit about the artist. That could be quite cool. But, I guess people would comment that. I don't think it's necessary to have that information pop up. It's more about people's discoveries, rather than this is this, this was created in this year and by this artist, it's not like an art gallery. You don't want to go and be told, you want to go and hear what [other] people think about it and their analysis.

5.4.6 Interview question 6

For the sixth set of questions, participants were told, *the goal of the app is to provide visual learning that can be present everywhere.* They were then asked, w*hat would you perceive the benefits of this to be?* P4 and P5 believed it would make them more aware of their surroundings and allow them to use their environment for learning. For example, P5 said:

> The value of it is it makes you notice all these little things and just like opens up the whole world to be a resource for learning. It doesn't just have to be online, or in a class, or in a magazine. It can be anywhere.

P1 saw it as developing positive habits germane to being a visual practitioner, commenting:

> It takes learning outside of the classroom and it's a good reminder that you actually do need to be appreciating this kind of thing [visual communication], and thinking about images and their meaning. I think sometimes it can be very confined to the classroom and assignments when you do think about this kind of stuff, but making it a habit and a routine is yeah, that's good.

P2 made similar comments:

> Making people more aware of their surroundings, I think that's a really important thing for everyone in terms of visual learning… I think it is really cool for people to be able to analyse it [their surroundings] and use that to heighten their learning ability and the content they are producing.

Participants were also asked if they perceived any negative effects this kind of ubiquitous learning might incur. Regarding the app, P1 said that they could "waste a lot of time scrolling through it and getting inspired instead of actually doing university work". P4 commented that negative attributes of the community could be present everywhere, such as if you were heavily down-voted, the community did not agree with your analysis, trolling, or receiving hate messages.

5.4.7 Interview question 7

The seventh set of interview questions were designed to elicit feedback on personalisation options that might not have been expressed throughout the scenarios issued earlier in the session. Questions asked what the participants wanted to be in control of and what kind of personalisation options they wanted. Participants voiced a desire for control over how they appeared online so they can manage their community image. This included a desire to change usernames freely, change profile pictures, to have a biography associated with their account, and the ability to curate what content would appear on their profiles such as arranging a gallery of their top posts. Participants noted that previous experiences with social networks that did not allow them to change these features were "annoying".

Participants were further asked if they would want a means to limit how often or when learning occurs. Both P2 and P3 raised issues around limiting notifications. P2 said they wanted something like Facebook Messenger's ability to mute conversations. P3 commented that they would turn the data off to the app as a means of limiting the app.

5.5 Chapter Summary

This chapter's focus is solely to report the outcome of the testing undertaken as part of the third stage of this research. The results include the participant's views on the premise of this research, the usability of the low-fidelity prototype, and the participant's views on the learning of visual literacy. The key findings are that the participants responded positively to most of the ideas reified in the tentative learning model. Participants believed that they can learn from the visuals they encounter in their own environments. They also believed the app would benefit their learning while also being fun and engaging. However, the findings indicate that the participants had some concerns and that both the tentative learning model and low-fidelity prototype could be improved upon. The following chapter further explores what these results mean.

Chapter 6: Discussion

6.1 Introduction

This chapter discusses the results and considers their significance to existing scholarship and the proposed learning model and app. This discussion includes refinements made to both the tentative learning model and low-fidelity prototype app following the test results. The discussion of the learning model is presented, based on its underlying pedagogical assumptions. The prototype is then discussed, beginning with an overall appraisal of the app to understand whether it has potential to be a successful means for learning visual literacy from one's environment. This is followed by a discussion of the identified usability issues, and how they were solved in the refined high-fidelity version of the prototype app.

6.2 Towards a Revised Learning Model

The following sections discuss the learning model, further exploring RQ1: *How can everyday encounters with visuals be leveraged as visual literacy learning opportunities by providing learning support?* Each section links a pedagogical assumption of the learning model to the results presented in Chapter 5 and to existing scholarship. Further, the pedagogical assumptions proposed by the tentative learning model are compared to the results to determine if they are purposeful, or if they need to be refined. Where a need for refinement is identified, refinements are proposed based on the results.

6.2.1 Visual analysis and learning

Lester (2011), Barnes (2011), Gombrich (1982), Velders et al. (2007), and Stokes (2002) all noted the importance of visual analysis in learning. Participants in this study corroborated this view by stating that they believed they learned when analysing visuals (Section 5.4.3). Before testing the app, participants were asked to recall a time they noticed a visual on the street and had given some thought to it. Every participant could recount an image and their thoughts on the visual, demonstrating they had remembered details and therefore gained some knowledge (Section 4.2.1). Participants were then asked if they believed they had learned from the encounter with the visual they described. Three participants stated they did not, while two stated they did. Of the two who stated they did, both mentioned either a desire for, or the importance of, collaborative analysis, believing that it allows them to understand their peers' perspectives, opinions, and interpretations which leads to their own learning. These responses align with the assumption that this research makes, i.e., that visual analysis as a learning practice benefits from collaboration. The results of the scenarios performed with the app also highlighted the importance of collaboration in analysis, with participants understanding the purpose of commenting as a means of sharing ideas to learn (Section 5.3.11). The participants perceived value in their previous experiences with collaborative analysis and were already involved with collaborative learning in informal settings, such as discussion with friends or participating in online forums (Section 5.4.4). Participants seemed to understand the need for collaborative analysis on some level given their desire for and active engagement in seeking support outside of the formalised learning they were receiving.

This research defined visual analysis in Section 1.3 as *a detailed methodological examination of the elements, structure, and surroundings of visuals, usually to interpret or explain them*. Although participants said they would offer their analysis of visuals while using the prototype, none did so in a manner that fits this definition throughout the sessions. The tagging and commenting system provided a *methodological* means for participants to *examine elements, structure, and surroundings* of a visual. However, the tagging and commenting system either did not allow or did not encourage any one single participant to offer a *detailed examination* as their interactions with posts were comparatively short (Section 5.3.11). This result may be due to the mobile device inputs being cumbersome, a point raised by Shudong and Higgins (2006) in their research (raised in Section 2.4.3). Participants' short interactions with posts may also be due to their expectation to only have short interactions with the app, as expressed in the results on personalisation options (Section 5.2.9). Even so, while individuals did not achieve a detailed analysis on their own, they did demonstrate that the prototype app's community could. While individual users may offer only short or incomplete analyses, the combined efforts of many users, i.e. the community of learners, potentially could, as each short individual analysis contributes to a detailed collaborative analysis. This was demonstrated by the participants in scenario 3 (Section 5.3.4), who all contributed unique tags and comments to a post. The division of effort in a collaborative analysis in mobile settings may be best practice for ensuring a detailed examination is achieved.

An interesting and unexpected result was that the participants repeatedly commented on a desire to analyse or engage with visuals that are either 'good' or 'bad' examples of visual communication (Section 5.3.11, 5.4.1, and 5.4.2). The results also showed a preference for 'bad' examples of visual communication (Section 5.3.11). A possible explanation for these results can be found in social-comparison theory, which posits that individuals will seek self-enhancement or improvements to their self-esteem by comparing themselves to others (Festinger, 1954; Wills, 1981). A person can compare through either an *upward* or a *downward* comparison. In a downward comparison, a person will look to another who they consider worse off as a means to feel better about themselves or their situation (Wills, 1981). A person will make an upward comparison with someone they perceive as better in some way as a means of self-enhancement, comparing similarities in themselves to the perceived positives of others (Suls, Martin, & Wheeler, 2002). From the results, it would appear that the participants were comparing themselves through their abilities as visual practitioners to those of others in the visuals they were noticing. Upwards and downwards comparisons may explain why the participants liked to analyse work that is notable for being either 'good' or 'bad'. Additionally, upward comparisons can sometimes have the opposite effect, decreasing a person's esteem as they may see themselves (or their skills as visual practitioners in this case) as inferior in the comparison (Suls et al., 2002). This may explain why some participants preferred to analyse poor examples, as doing otherwise may negatively affect their self-worth.

Understanding visual analysis can be affected by social comparison; upward and downward comparisons appear to be a motivating factor in this learning model. Therefore, the first point of the learning model has been refined to recognise the importance of analysing noteworthy examples of visual communication, whether they are good or bad. The first pedagogical assumption has been refined to:

> **Conducting visual analysis of noteworthy examples of visual communication within a learner's environment provides a means for learners to more deeply engage with visuals and learn from them.**

6.2.2 Inclusivity of understandings

The second pedagogical assumption of the tentative learning model, *learning must be inclusive of the different understandings of visual literacy*, recognises that there are many domains and schools of thought on visual literacy. Avgerinou and Ericson (1997) cited this as a problem for visual literacy, and Griffin (2008) cited this as a problem for visual communication (Section 1.3). The results in Section 5.4.1 show that participants understood there are multiple understandings or ways of interpreting visuals, and all said they were receptive to this diversity of ideas. If learners were not receptive to the thoughts or understandings of others, then the learning community would most likely become dysfunctional. Further, a community that could not support a variety of understandings would make it difficult to provide personalised learning. While the results are positive, the unilateral acceptance of different understandings as demonstrated by the participants appeared to be due to the introduction to the visual communication course those participants were recruited from. Given that inclusivity of understanding is important for this learning model, this may suggest that some basic prior knowledge may be needed to engage with learning in the manner that this learning model describes. This prior knowledge does not necessarily mean formal training however, as it could be provided as an onboarding exercise in the implementation of this learning model.

The results do raise some points of caution about the learning model. Two participants noted that although they understood that there are multiple understandings, they would need these views to be supported in some way before they would be receptive to them (Section 5.4.1). Essentially, these participants were not concerned with the ‘correct’ understanding, but rather the quality of explication. Given the informal and rhizomatic approach that underpins the learning model, what constitutes quality would be a decision made by the community through discussion and self-moderation, using whatever tools the online community has available. In a best-case scenario, learners would debate ideas constructively, with peers asking for further explanation resulting in an analysis supported or rejected by the community. This process would see learning occur as a form of Vygotsky’s (1978) social constructivism (Section 2.5.1) as is intended by this learning model. In the worst-case scenario, differences in opinion among the learners within the community may result in disagreements rather than discussion, leading to cyber bulling, personal attacks, trolling, or flame wars, which was a concern raised by one participant (Section 5.2.6). This comes down to “Godwin’s law”, an internet adage that states “as an online discussion progresses, it becomes inevitable that someone or something will eventually be compared to Adolf Hitler or the Nazis, regardless of the original topic” (Oxford Dictionaries, n.d., para. 1). Therefore, application of this learning model should consider how to minimise off-task interactions such as these personal attacks.

A potential issue was identified with the pedagogical assumption regarding inclusivity of understanding. While participants said they were receptive to the views of their peers (Section 5.4.2), a later question revealed that some would be hesitant in offering views in disagreement with others (Section 5.4.3). This could lead to incorrect interpretations gaining traction as potentially no one challenges them. Cheong et al. (2012) reported a similar problem within online learning communities called *groupthink*, where learning communities tend to agree rather than offer a diversity of ideas. Groupthink is also a known issue with other existing online communities using up-vote systems, such as Reddit and Digg, where the first up-votes or down-votes will likely set a trend for following votes (Muchnik, Aral, & Taylor, 2013). This issue may also extend to visual perception. A study by Asch (1955) found that a person could easily be made to ignore their own correct perceptions in favour of group consensus. Diving deeper into the results reveals conflicting data however. One participant stated that they would only comment in disagreement, believing if they agreed with a comment they would just up-vote it and there would be no need for their additional to comment (Section 5.4.3). Also, some participants noted that the purpose of such a platform as this research proposes differs from social media in that it is not there as a channel to make everyone happy, but to engage with critical analysis (Section 5.3.11). The difference in opinion on commenting in disagreement appeared to be the result of a different understanding of the purpose of commenting. Therefore, although some participants' responses indicated that groupthink may be a problem, others did not. Any application of this learning model would need to monitor the community for issues of groupthink, and may consider educating its user-base to avoid problems (such as through onboarding).

An unexpected benefit of the prototype tag/vote system is that it offers users an anonymous means to like and dislike specific user-defined aspects of visuals using the tag system. This feature was intended to create discussion, focus comments, and offer basic critique for those short on time by isolating specific features or aspects of a visual for liking or disliking. The tags essentially 'deconstruct' a visual for consideration, and therefore require some thought before each tag can be understood in relation to its associated visual. This extra thought or consideration over standard up-vote or like systems may help overcome groupthink as it forces one to pause and consider multiple facets for liking or disliking, rather than simply liking or disliking the visual as a whole. Also, as some participants noted (Section 5.3.11), the likes and dislikes do not relate to the users, but rather to the work they post. For example, a user may post a poorly constructed image with the expectation that others will dislike its aspects, rather than like their post.

In recognition that groupthink might be a potential problem, the learning model should not only encourage learners to be receptive to different understandings, but also encourage them to impart different understandings. Therefore, the learning models second assumption should be:

Learners must impart and be receptive to different understandings of visual literacy.

6.2.3 Collaborative learning

Collaboration and learning communities are central to this learning model. The rhizomatic component of collaborative learning means the community not only exists for learners to interact and access learning content, but also to produce learning content. Therefore, the collaborative component of this model is core, as it provides both the mechanism and material for learning to occur in the intended informal setting.

Participants positively perceived learning visual literacy skills in collaborative settings. Further, participants reported that online collaborative learning for visual literacy is fun, interactive, entertaining, and engaging (Section 4.4.4). Clearly, the participants perceived value in the social aspects of learning this way. This result is similar to those of Gikas and Grant (2013), who have reported about positive learner perceptions of social media used in learning, and Cheong et al. (2012), who noted Millennials perceive online social interactions as enjoyable in learning. Participants that report the community setting as engaging is of interest to this learning model. Cheong et al. (2012) believed that increased engagement promotes higher-order thinking, such as critical thinking, which according to Lester (2011) is core to visual analysis. Therefore, the collaborative aspects of this learning model promote visual learning. These results provide initial indications that the third pedagogical assumption of this learning model is purposeful and can remain as:

Learning visual literacy is a collaborative activity.

The framework and medium for online communities provides the creator some measure of control, and the means for the community to self-moderate. According to Dillenbourg (1999, p. 6), “interaction rules can be continuously reinforced by encompassing them in the design of the (computer-mediated communication) medium”. Therefore, three supplementary assumptions to describe and set rules for the learning community were included in the third pedagogical assumption. These are: a) *provide a community to facilitate collaborative learning*, b) *make learners aware of social factors*, and c) *the learning community should be decentralised*.

The first supplementary assumption, *provide a community to facilitate collaborative learning*, is about affording a space for collaboration germane to learning to occur. Cheong et al. (2012) reported that there is principally a potential for lack of focus, poor communication, dominant personalities, social loafing, and groupthink within learning communities. However, Dillenbourg (1999) stated that a means to limit off-task interactions can be implemented and interactions that lead to learning should be encouraged. Dillenbourg (1999) noted that limiting off task interactions can potentially increase the perceived value of the community, as new users will see interactions related to learning. Participants confirmed this, perceiving the value of the app as coming from the community (Section 5.4.4) and the success of the app is dependent on its user base (Section 5.3.1).

The prototype app implemented the ‘tag then comment’ system to promote task-focused interactions, which participants responded positively to (Section 5.3.11). Participants also perceived the apps up-voting system as a potential means to motivate the community to contribute with comments and help (Section 4.4.3). This result opens the learning model to notions of gamification. Gamification is the idea that mechanics used in games can be used in non-game contexts as a means of increasing user engagement and motivation (Domínguez et al., 2013). The mechanics used in gamification have already been studied in e-learning applications by Muntean (2011) who reports that accumulating points, such as the up-votes in the participant's revelation, may be used as a means of rewarding behaviours and encouraging tasks within a learning community. In addition to point scoring, gamification also commonly uses levels, leader boards, badges, onboarding, challenges, social engagement loops, and customisation options to increase engagement and motivation (Zichermann & Cunningham, 2011). Onboarding, social engagement loops (occurring as notifications on activity), and customisation options were also present in the prototype app, which were all received positively by the participants.

Participants said they would seek help from learning communities and demonstrated they would seek help when using the prototype app (Sections 5.3.5 and 5.4.3). As noted in the proceeding sections, novice learners are likely to need support for visual learning to occur. Vygotsky (1978) stated that this support can come from more capable peers. Thus, this learning model operates on the assumption that learners will help each other by engaging with and adding to collaborative visual analysis according to their respective skill levels. Given the informal learning setting however, it is up to individuals to seek help from peers, as no one is formally assigned the role of monitoring learners to determine if they need help. If learners were not willing to seek help, then they would receive none, which may negatively impact on their learning. Although the results suggest that learners would seek help, this behaviour could be further reinforced by offering an incentive through gamification.

The results seem to indicate that gamification is a suitable means to motivate learners to engage with the learning community. Therefore, the first sub-point has been altered to:

> **Provide a community that uses gamification mechanics to encourage collaborative learning.**

The second supplementary point to the third pedagogical assumption, *make learners aware of social factors*, is about providing a shared context for learners to socialise, learn, and construct knowledge. Section 2.4.2 asserted that to achieve coordinated collaboration learners must be made aware of social factors which consist of who is around, what is going on, and how things are going. Participants were asked what social factors they would want to be made aware of, both as part of this learning model and when using the prototype app. Participants spoke most about the ability to learn along with friends (Sections 5.3.2, 5.4.2, and 5.4.4), perceiving this as motivational and fun. Participants also wanted to be informed of anything to do with themselves, such as replies to their own comments or posts (Section 5.4.4). These results are not surprising, as Gikas and Grant (2013) reported similar findings in their studies. It would appear that Millennials enjoy social media, and positively associate these aspects of social media with m-learning. An unexpected result was that participants also spoke of receiving notifications from celebrity activities, whether they be a famous personality for their exploits in popular culture or famous within the learning community (Section 5.4.4). There was also a desire to receive notifications on trending discussions within the community (Section 5.4.4). These notification features are typical of what you would find in most social media platforms, and suggests learners wanted similar community features to that which they receive through social media, despite the education or m-learning focus. The responses reflect the opening arguments of this thesis (Section 1.2), that how information is received in the contemporary world is changing. This shift towards social media can be seen documented in other fields, for example, the Pew Research Center (2014) reported that half of all social media users in 2014 engaged with the news through social media channels. The change in the media landscape appears to also be influencing learner expectations and suggests that the social elements of the learning model may appeal to Millennials because of their exposure to social media.

A desire for locational social factors was also mentioned by participants. Responses on highlighting are discussed later in Section 5.2.6. Aside from highlighting, there was a desire to be made aware of social factors based on their locational context (Section 5.4.4). For example, the participants wanted to be made aware of friend's activity, but only if the friend was within the proximity of the user. This demonstrates a potentially unique aspect of this learning model; the use of location in context to community activities. Given participants wanted this feature, this would constitute an additional engagement mechanism for this learning model not identified in the initial synthesis of the tentative learning model. Therefore, the refined learning model should make learners aware of social factors based on location also.

As social factors regarding location are uncommon and are rarely mentioned in scholarly discussions regarding social factors, it justifies making locational social factors explicit in the learning model. Therefore, the second supplementary point to the third pedagogical assumption, *make learners aware of social factors*, has been modified to ensure locational social factors are not overlooked. The supplementary point also lists the social factors, identified as important by participants above, namely, anything relating to their own activities, the activities of their friends, and anything related to their interests. The third pedagogical assumption's second supplementary point was therefore modified to:

> **Make learners aware of social factors, relating to their own activities, friends, interests, and location.**

A privacy issue was raised by one participant, who felt disclosing their locational activities could be a risk (Section 5.3.6). To elaborate; as a post is made, community members would be alerted to that user's activity and thus see (by means of the post) the user's present location. This same problem also exists on social networks such as Snapchat, Facebook, and Instagram, which all address this problem with the ability to opt-out of geo-tagging. In the case of this learning model however, the geo-locational data is needed to locate and highlight visuals for other learners to engage with. Solutions to this problem could include delayed posting, remote geo-tagging, anonymous posting, and privacy settings. Each of these solutions presents their own unique challenges however. The option to delay a post would allow users to obfuscate their current location. However, other users could post the same item during a post delay, leading to duplications which might divide discussion and analysis across separate and distinct posts of the same artefact. Remote posting would allow participants to post while being physically located somewhere else. However, this opens the system up to incorrectly geo-tagging posts which might have the follow-on effect of incorrectly highlighting visuals, and in this way devaluing the highlighting feature for the entire community. This would also go against the idea of contingent and situated learning that this learning model adopts. Allowing anonymous posting would overcome the problem. However, anonymous posting might create more serious issues, as anonymous online communities often become platforms for hate speech and cyber bullying (Hyde, 2000; Thomas, 2006). One only needs to look at the now defunct geo-located social network "Yik Yak", or the online forum "4chan" to confirm this. Privacy settings could be used to limit a post's visibility to trusted communities, such as friends or family, as one participant suggests (Section 5.4.1), but this would constrain learning resources available to individuals in the community and minimise contributions to visual analysis.

It would appear that there is no clear solution to the privacy issues arising from geo-tagging. However, privacy issues and their lack of solutions are not unique to this project and are widely reported among users of online communities and social media (Hargittai & Marwick, 2016). Fortunately, this fear of privacy loss would not be likely to prevent most learners from engaging with the learning embodied by the app and learning model due to the *privacy paradox*. The privacy paradox is where online community and social media users know the privacy risks involved but still choose to engage with such services anyway as the perceived benefits outweigh the perceived risks (Hargittai & Marwick, 2016). Hargittai and Marwick (2016) attribute this to user apathy and cynicism surrounding online privacy issues, as users may believe privacy violations are most likely inevitable and opting out is not a realistic option.

Privacy is essentially about control of personal information, and ideally, that control should lay with the user (Cavoukian, 2012). However, further discussion of privacy is outside the scope of this research as it would require a business model and functional app to continue the discussion in relation to this specific research. For example, the research could propose that the app adheres to Cavoukian's (2012) principles of "Privacy by Design" (PbD). PbD is an ideological framework that proposes that privacy assurance should be an organization's default mode of operation. However, such frameworks are designed to encompass "1) IT systems; 2) accountable business practices; and 3) physical design and networked infrastructure" (Cavoukian, 2012, p.16). As this research only develops a non-functional prototype, the facets of IT and business practices needed to discuss privacy in a meaningful way in relation to this specific study are outside the scope of this research.

The third supplementary point to the third pedagogical assumption, *the learning community should be decentralised*, is included so that a learning community may have autonomy to organise itself. This provides a means for the community to socially construct knowledge rather than have it set by an individual or curriculum designer. The usability testing sessions collected participants' views and actions relating to the app's mechanisms for providing a decentralised system, namely, the tag system, up-vote system, posting and commenting (reported in Sections 5.3.11, 5.4.1, 5.4.2, and 5.4.5). These features were perceived positively as a means for the community to come to consensus about what is desirable content. Also, the decentralised nature of the app was seen positively in relation to the learning model's informal nature. To elaborate with a quote, participants did not want to "be told" (P1, Section 5.4.5), as they can receive this style of directed learning in classes or existing instructional resources such as Google Field Trip or Empedia (discussed in Section 2.2.5). Instead, they preferred the way in which differing opinions could be voiced on the app, leaving the individual user to ultimately decide what they believe is correct or useful. The positive responses provide indications that this third supplementary point to the third pedagogical assumption is correct and can therefore remain as:

The learning community should be decentralised.

6.2.4 Contingent learning encounters

The proposed learning model operates on the premise that visual communication is ubiquitous in a learner's environment and can be leveraged to acquire visual literacy skills. For this to occur, learning must be situated in a learner's environment, taking advantage of contingent learning opportunities. The fourth pedagogical assumption, *learning is triggered by contingent encounters with examples of visual communication in a learner's environment,* along with the fifth and sixth pedagogical assumptions, uses ideas of situated and contingent learning to leverage everyday life as visual literacy learning opportunities. Results in Section 5.2.2 and 5.4.6 show that participants responded to the idea of learning from contingent encounters with visuals in their environments positively, believing they all could learn this way, with some of the participants already doing so. The results in Section 5.2.1 also demonstrated this to be the case, as participants all recounted a visual they had seen in their daily environment that they had given some thought to.

There was also a disconnect however, between the participants' experiences and their reflections on these experiences regarding their learning from contingent encounters. During the warmup questions, participants were asked to recount a contingent encounter with a visual they had given some thought to. All participants did, providing visual details and interpretations of their encounter. The ability to recall details of visuals demonstrated that the participants' experiences of contemplating an encountered visual helped to internalise the visual, which Lester (2011) claimed is a form of visual learning. This could also be considered a form of experiential learning, as experiences are internalised therefore resulting in learning. However, when the participants were asked if they believed they had learned from past contingent encounters with visuals, only two participants believed that they had, while the other three described the experience as one of appreciation or practice. As practice is a means to refine and expand on learning through application, this therefore raises the question of what the participants perceived as learning. One participant's responses mirrors this disconnect as they speak of using Pinterest (a social network for viewing and curating images) specifically for helping with their studies, but stated this is not learning as it does not teach formal rules or how to achieve some specific technique (Section 5.2.3). This participant appeared to perceive learning relating to the creation of visuals as learning, and everything else was not learning. This may be a consequence of being a novice learner engaged with formal learning, and hence not perceiving anything outside their current learning objectives as learning. If this were the case, then the difference in participants' perceived learning from contingent encounters may be due to varied levels of expertise. Another potential reason for this disconnect may lie in notions of tacit knowledge. Rourke and Rees (2015) claimed that tacit knowledge is often gained through experiences (such as contingent encounters), which leads individuals to develop intuitive visual skills that are subconscious and implicit. If this were the case, then the participants in this study may not be conscious of their learning. Results regarding the reception of the app (Section 5.3.1) also point to this possibility, with one participant commenting that they liked the app as, "it doesn't even really feel like learning".

While participants' comments confirm that learning can be triggered by contingent encounters with visuals they had noticed, this activity may require support, as some participants asked for knowledge, such as others' analyses, to accompany contingent encounters (Section 5.2.2). This result aligns with the visual learning circular reference system introduced in Section 1.4, whereby perception and visual analysis require and are influenced by memories and experiences, but memories and experiences are created through perception and visual analysis (Helmholtz, 1925; Jamieson, 2007; Lester, 2011). One entry point into this circular reference are peers imparting knowledge or highlighting visuals (Figure 1-3). The participants' desire for knowledge to accompany visuals appears to confirm the entry point into the circular reference system created by peers imparting their knowledge. Therefore, while this result does not oppose the fourth pedagogical assumption that *learning is triggered by contingent encounters with examples of visual communication in a learner's environment*, it does demonstrate that the pedagogical assumption may not be effective in isolation as there needs to be support in the form of peers imparting their knowledge. The data collected indicates that the fourth pedagogical assumption is purposeful to the learning model and can remain as:

> **Learning is triggered by contingent encounters with examples of visual communication in a learner's environment**.

Another concern is motivation. The results in Section 5.2.2 show that while one participant stated high levels of motivation and that they currently practiced learning by analysing contingent encounters with visuals, another said they could only learn this way if they were "motivated to do so" or if there was some "reward at the end". These differences in motivation are most likely a result of the learning model being a form of self-directed informal learning. In self-directed learning, intrinsic motivation by the participants to learn is critical as there is little or no external motivational force encouraging them to learn (Song & Bonk, 2016). Thus, learners must take the initiative to learn themselves. Consequently, learners using this model may need to be intrinsically motivated to learn to engage with some aspects of this learning model. Issues of learner motivation and how it may be positively influenced in this learning model are discussed further in other pedagogical assumptions, specifically those that deal with gamification mechanics, exploration, highlighting, and personalised learning.

6.2.5 Examining one's environment

As discussed in the preceding section, real-world encounters with visual communication serve as triggers for learning in this model. The fifth pedagogical assumption, *learners need to examine and investigate their environment's examples of visual communication as a means of learning*, encourages learners to seek out encounters with examples of visual communication under their own direction. This pedagogical assumption was confirmed as purposeful, as some participants claimed to currently practice visual literacy by exploring their environments, applying existing knowledge to uncover connections, new knowledge, and deeper meanings of visuals. This situates this type of learning as a specific branch of constructivist learning called discovery or exploratory learning, which is based on the premise that our experiences shape or refine our knowledge and allow us to understand the world (Bruner, 1986). Discovery or exploratory learning encourages learners to examine and investigate new material or experiences, to discover relationships between existing knowledge and unfamiliar content, and concepts leading to learning (Bruner, 1961).

As noted in the proceeding section, a common theme in the result is that participants believed they needed some prior knowledge to be able to explore as a means of learning, and that they needed to be engaged with formal education to acquire this prior knowledge (Sections 5.2.1, 5.2.2, and 5.4.4). This result appears to confirm the visual learning circular reference system. The prior knowledge gained from formal education represents an entry point into the circular reference system, which, given the results, the participants understood on some level. One participant demonstrated this as they stated they could not learn without support because they felt they lacked the knowledge or confidence in the knowledge they had (Section 5.2.2). This again highlights the importance of prior knowledge, as without it, exploration may be too much of a challenge for some to undertake. Therefore, any implementation of this learning model may need to be supplemented with some type of formal education. This need to supplement with formal learning appears to be indicative of a wider problem with m-learning, which, according to Crescente & Lee (2011), lacks evidence that it may stand in isolation, and is why m-learning is frequently implemented with other pedagogical strategies.

Another pattern in the participants' responses in sections 5.3.1 and 5.4.5 was that they believed exploring their environment for examples of visual communication was a valuable habit, a good means to practice, or a best practice. While not enough data was collected to make any claims on the efficiency or effectiveness of exploring one's environment as means of gaining visual literacy, it is clear that participants perceived high value in this practice. In a study by Park and Choi (2009), they found that a learner's perception of usefulness had a positive impact on their motivation to continue learning in a digital setting. Consequently, the participant's perception of value can be regarded as an intrinsic motivator. The perceived value and consequent intrinsic motivation provides impetus to engage with learning that offers no accreditation or appointed pedagogue to provide motivation, which makes a strong case for the learning model's application in informal settings.

Given the positive reception by participants and the alignment with existing scholarly knowledge discussed, the fifth pedagogical assumption shows strong indications of being purposeful and can remain as:

> **Learners need to examine and investigate their environment's examples of visual communication as a means of learning.**

6.2.6 Highlighting

Section 6.2.4 discussed that learning is triggered by encounters with visuals. This section discusses the sixth pedagogical assumption to, *provide a means to highlight or direct learners to examples of visual communication*, which means to create opportunities for learning encounters to occur. The results in Section 4.4.5 showed that the participants responded positively to the idea of highlighting, perceiving it as both beneficial to their learning, and as an aid in developing habits they believed would be valuable as a visual practitioner.

Highlighting represents the second entry point into the visual learning circular reference system introduced in Section 1.4. Highlighting can be used to direct a learner to select (a visual) and begin the learning process using visual analysis. Whereas the fifth pedagogical assumption, *learners need to examine and investigate their environment's examples of visual communication as a means of learning*, requires prior knowledge to select a visual for learning to occur, the sixth pedagogical assumption on highlighting provides support for learners who lack prior knowledge, confidence, or the ability to select visuals to analyse. The need for highlighting was confirmed by one participant, who felt they would struggle to learn from their own explorations. This participant gave an account in which an advertisement was pointed out to them, which they subsequently analysed and learned from (Section 5.2.2). In this account, the participant's analysis and consequent learning were the result of the image being highlighted for them.

Highlighting may also play a role in combating habituation, i.e. the idea that one's mind tunes out stimulus that is constant, repetitious, and predictable (Bloomer, 1990). Highlighting can act as a prompt to engage learners when they are inattentive to their environment. Participants responded to highlighting favourably, commenting that they often became inattentive to their environment while 'running errands and completing tasks', and it would be beneficial to have a reminder to appreciate the visuals surrounding them (Section 5.4.5). As highlighting provides a prompt, it can therefore be considered an external or extrinsic motivator rather than an intrinsic motivator. Extrinsic motivation reflects on activities undertaken for external reasons (Riaz, Rambli, Salleh, & Mushtaq, 2010). Extrinsic motivators are often not present in informal learning, as informal learning often has no obvious external force to encourage learning activities (Riaz et al., 2010). This demonstrates an uncommon and beneficial facet of this learning model, the ability to provide extrinsic motivators in informal learning settings.

While using the prototype, a common theme was noted that participants believed highlighting would be fun (Section 5.3.3). Although highlighting was intended to engage learners when inattentive or unaware of visuals in their environment, participants also perceived highlighting as an enjoyable mechanism to actively engage with. Participants envisioned themselves using highlighting like a radar or map to actively seek out visuals, then changing their location to experience those highlighted visuals. Participants drew comparisons to playing mobile games that use similar mechanisms. In particular, three participants mentioned the app Pokémon Go (Section 5.3), which was released a month prior to the user testing sessions. Pokémon Go is a mobile game with the goal being to seek out and capture monsters (Pokémon). The game places monsters throughout a user's environment, and when a user is in close enough proximity, they are highlighted so a user can interact with them. The proximity-based highlighting of Pokémon Go was like how the prototype app bought posts to a user's attention. The comparisons drawn between the prototype app and Pokémon Go by participants show that highlighting has the potential to be fun and engaging.

The results and their analysis show indications that this pedagogical assumption is correct and can remain as:

Provide a means to highlight or direct learners to examples of visual communication.

A surprising result was the duration and frequency that participants imagined they would spend with images that the app would highlight. Most participants expected short and frequent interactions. At the upper end, participants expected visuals to be highlighted up to twenty times a day, with each interaction occurring for only a few seconds (Section 5.4.5). The assumption to only briefly interact with visuals, however, does not mean one could learn this way. Visual analysis is the primary mechanism used in this learning model for internalising learning, which is by definition, a detailed and methodical process (Section 1.3). It is doubtful that a learner could undertake a detailed and methodical analysis in a matter of seconds, and learning this way would most likely not be effective. The explications of participants for short interactions with visuals however, did not match their actions. While testing the prototype app, the participants engaged with images for much longer periods of time. The comments and interactions on the learning community held participants' attention for much longer periods of time during reading, liking or disliking tags, upvoting or downvoting comments, replying to comments, and making comment themselves (Section 5.3.11). Consequently, highlighting on its own may not be enough to hold a learner’s attention long enough for learning to occur. The actions of participants show that additional information or interaction is needed to engage and hold a learner’s attention long enough for them to internalise learning. This result also poses an interesting question – how long does it take on average for a visual to be analysed for learning to occur? According to Helmholtz (1925) and Lester (2011), more experience translates to a heightened ability to perceive, therefore, the duration of analysis should decrease with experience. However, this research collected no data on visual analysis durations and their effects on learning gains, so exact lengths are unknown. The combination of learning, visual analysis, and time spent also does not appear to have been explored by other studies.

An interesting thought on the frequency and duration of highlighting was raised by one participant who thought the same visuals would be highlighted each time they passed it with varying frequency and duration (Section 5.4.5). The participant imagined each pass would provide another opportunity for analysis to occur, seeing the process potentially happen over days, with each highlight occurrence allowing more to be understood of the visual. The participant perceived this practice would not require long durations to be spent with visuals, and would allow analysis to percolate in the back of their minds in-between viewings. Research by Bromage and Mayer (1986) on repetition in learning showed a positive correlation between repeated readings of material and recall of information. The participant also mentioned that each new interaction with the same visual could be potentially shorter than the last. Again, Bromage and Mayer's (1986) research gives validity to this assumption, as each repeated reading resulted in fewer learning gains, which justfies less time spent with each repetition of material. These findings suggest that repetitive viewings of a visual with subsequently less time spent per viewing may be an effective means to gain visual literacy. However, this still does not answer the number and duration of viewings that are optimal for visual learning and further research is required before any conclusive claims may be made.

6.2.7 Ubiquitous learning support

The tentative learning model’s seventh pedagogical assumption, *provide ubiquitous access to learning*, allows learning to occur anywhere and anytime. Participants liked the idea of ubiquitous learning, believing it would allow the ‘whole world’ to become a learning resource (Sections 5.3.1 and 5.4.6). Participants expressed excitement about being able to fit learning around their daily activities (Sections 5.3.1 and 5.4.6). When considering the significance of ubiquitous learning in the learning model, it allows for contingent and situated learning, which are key elements in the preceding three pedagogical assumptions. Consequently, participants attached value to ubiquitous learning for the same reasons they attached value to the preceding three pedagogical assumptions; paying attention to and learning from visuals in one's environment is a good habit or best practice.

The idea to implement ubiquitous learning came from what is already anecdotal knowledge to most visual practitioners, i.e. that there are visuals all around that one can use to deepen their understanding. Story (2007) stated that visuals in the form of ads can be encountered almost everywhere the eye can see and statistics representing time spent shows the average person consumes large amounts of visual media daily, such as 279 minutes of television, or 169 minutes of internet browsing (see Figure 1-1). The missing aspect from visual literacy literature is how one can use these visuals to learn, given their informal setting. Participants believed they could learn in a ubiquitous setting, however, they either desired or felt they required learning support. Therefore, there are strong indicators that learners can learn from the images within their environment provided they have direct access to learning support. To account for this, the seventh pedagogical assumption has been changed to stress the importance of readily available learning support:

Provide ubiquitous access to learning support.

An issue of concern was that the ubiquitous nature of learning under this model may potentially be perceived as intrusive by learners. Motiwalla (2007) noted that m-learning's anywhere and anytime nature can be intrusive for some learners. Gikas and Grant (2013) noted that mobile devices are personal devices that learning can be perceived to intrude on. As noted above, visuals can be encountered almost everywhere the eye can see, therefore, the learning interactions that leverage these visuals can also be almost everywhere the eye can see as well. The ubiquity of learning opportunities raised concern with the researcher that participants might feel that their lives are being intruded on by prompts such as highlights or social factors. In contrast to these concerns, the participants felt there would be no such problem, as they would have enough control provided by the app to limit interactions according to their preference. This result aligns with existing research by Jeong and Hong (2013) which shows the effectiveness of ubiquitous learning is positively influenced by providing learners the ability to personalise their learning.

As discussed in Section 6.2.2, participants voiced their concerns about trolling and bullying. In regard to online attacks, one participant noted that the potentially negative attributes of an online community would have the potential to be as ubiquitous as any other part of the learning experience (Section 5.3.6). Yang (2006) stated that ubiquitous learning provides the means for learning collaborators, learning contents, and learning services to be pervasive and seamless in a learning environment. Therefore, it is conceivable that ubiquitous learning could allow bullies in the guise of collaborators to be pervasive and seamless in another's life. This is concerning as similar problems occurred with Yik Yak, the geo-located message board app. Yik Yak became a forum for hate speech on college campuses in 2015, which saw many colleges ban the app and block access to it through their networks (Johnston, 2015). The problems from Yik Yak stemmed from its anonymous nature which allowed bullies to hide (Johnston, 2015). Yik Yak responded by voluntarily disabling their services near schools and no longer allowing anonymous posting. However, the damage was irreversible, as Yik Yak's user base declined and the service was discontinued. Therefore, it is advisable that any implementation of this learning model should not include anonymous posting, as noted earlier in Section 6.2.3. This also reinforces the importance of providing preference settings (discussed in Section 6.2.9) and tools for the community to self-moderate (discussed in Section 6.2.3) so that community members may avoid and discourage negative behaviours.

6.2.8 Context-aware learning

Gombrich (1982), Barnes (2011), and Lester (2011) stated that context, i.e. the circumstances or environment for a visual message, needs to be considered when undertaking visual analysis. This presented a challenge for this learning model, because it is applied in a learner's unique and ever-changing environment. The eighth pedagogical assumption, *provide context-aware learning*, was included to solve this challenge. According to Basaeed et al. (2007), context-aware learning can dynamically change to reflect variations in the circumstances or conditions that surround a learner. The inclusion of this pedagogical assumption requires the use of a device such as a smart phone, to poll contextual information such as location, time, and a visual's surroundings. This consequently situates this learning model as a specific implementation of m-learning due to its reliance on smart devices.

The results in Section 5.4.6 revealed the contextual information participants wanted to accompany the visuals. Roughly half the participants answered with a desire for the history or background information of the visuals, for example, who made it and why. However, one participant suggested that contextual information should be socially constructed. This socially constructed contextual information was imagined to be whatever the community wished to add about the visual, which in turn could be engaged with conversationally to clarify or modify meaning. Further, this participant perceived a system that provided set contextual information such as that voiced by the other participants (history, background, artists biographies), would be poor experience consisting of ‘being told’ rather than actively participating in the learning. This split of participants’ opinions has deeper pedagogical roots, mirroring the dichotomy observed between behaviourist and constructivist pedagogies. Behaviourist pedagogies involve “being told” through the transfer of knowledge from expert to novice (Hung, 2001). Constructivist pedagogies are based on the learners’ active role in learning, whereby they consequently construct knowledge (Leidner & Jarvenpaa, 1995). Due to the active role of the learner in constructivist pedagogies, the learner often has more control and learning can be more engaging (Hung, 2001; Leidner & Jarvenpaa, 1995). Learner control and engagement are important considerations in informal learning. Hence the constructivist pedagogical model is more suitable for this learning model. The preference for constructivist learning in informal settings may also explain why platforms such as Google Field Trip or Empedia, which consist of ‘being told’, never gained much traction. While these apps use proximity-triggered notifications, like those in the prototype app, the experience of using them is passive. Therefore, the context provided should be socially constructed. As the third pedagogical assumption already stated, knowledge is socially constructed – it would be redundant then to include the notion that context is socially constructed in this pedagogical assumption also. Therefore, the eighth pedagogical assumption is suitable as a component for this learning model, and remains as:

Provide context-aware learning.

The most discussed context feature throughout the usability testing sessions was that of location (Sections 5.4.2, 5.4.4, and 5.4.5). This was an expected result, given Millennials’ exposure to social media, in which geo-tagging photos and posts on platforms such as Facebook and Instagram is common. Geo-tagged context is used by the app as a means of highlighting visuals. However, participants also envisioned this as a means to browse content. The findings show that the potential for learning in this model not only considers the learner situated in their physical environment, but it also considers the learner to be remote and accessing a location through some digital means. This was an appealing proposition to participants who liked the idea of checking out locations they did not inhabit. The curiosity to see remote locations could be used as a motivational force to engage learners with visuals.

6.2.9 Personalised learning

Pedagogical assumption nine is that, *learning needs the ability to be personalised to accommodate a learner’s environment, goals, interests, and preferences*. The subject of preferences has already been touched on in preceding sections, as the topic is embedded in the discussion of some of the other pedagogical assumptions, namely; being inclusive of the different understandings of visual literacy, allowing for a decentralised community, and allowing for control so that ubiquitous learning can occur (Sections 6.2.2, 6.2.3, and 6.2.7).

Personalised learning provides motivation according to gamification theory (Zichermann & Cunningham, 2011) and intrinsic motivation to learn according to Fazey and Fazey (2001), Ghauth and Abdullah (2010), and the APA Work Group of the Board of Educational Affairs (1997). Participants' responses were however inconclusive in confirming this (Sections 5.3.12, 5.4.4, and 5.4.7). The participants liked that they had preference settings to control how they learned, however these preferences appeared to be expected features rather than motivators. This can be understood by applying Herzberg's (1968) hygiene motivational theory about the workplace, which posits that there are factors responsible for job satisfaction and an independent and separate set of factors responsible for job dissatisfaction called *hygiene factors*. The notion of hygiene factors has been applied and proven in user interface design by Miraz, Excell, and Ali (2016), who showed that some features, if included, do not contribute to satisfaction, but when excluded or neglected lead to dissatisfaction. The findings in Sections 5.3.12, 5.4.4, and 5.4.7 quote participants becoming "annoyed" when personalisation features had been neglected on social media networks, and would become "pissed off" if the proposed app also neglected such personalisation options. The "annoyed" and "pissed off" responses appear to indicate that the personalisation options discussed by participants are such hygiene factors. These findings may also indicate a wider implication that learners' expectations have shifted. Whereas in 2001, Fazey and Fazey claimed personalisation could increase learner motivation, Millennials observed in this study have had longer exposure to social media, where such features are common place. This may have normalised or created expectations for features such as personalisation options, which may have once been perceived as unique.

While the results are inconclusive in confirming the motivational claims other researchers have made regarding personalised learning, they do show that the participants desired personalised learning and controls. Therefore, the ninth pedagogical assumption remained as:

> **Learning needs the ability to be personalised to accommodate a learner's environment, goals, interests, and preferences.**

The ninth pedagogical assumption's sub-point, *personalising learning needs to also include means to limit learning*, is a response to scholarship from Motiwalla (2007) and Gikas and Grant (2013), who believed m-learning's anytime and anywhere learning can potentially overwhelm learners and intrude on their personal space. Highlighting seemed particularly vulnerable to these problems, as it sought to implement learning that would provide learning opportunities as numerous and persistent as visuals are. This is not practical and could overload a learner. Motiwalla (2007) also warned that this may lead to habituation i.e., the idea that we tune out repetitive stimulus. Habituation would result in prompts being ignored, or simply make learners disengage altogether. The inclusion of a supplementary assumption to limit learning was justified when one participant commented that if notifications ever became intrusive, they would turn off data on their mobile app to disable them (Section 5.4.5). This would be a poor outcome, as learners would not receive any prompts about visuals in their environment and disengage from learning. Further, participants desired different levels of notification. While one participant wanted up to twenty daily notifications, another only wanted one a week and felt that receiving more may be problematic (Section 5.4.4). These findings confirm the caution Motiwalla (2007) and Gikas and Grant (2013) reported, and demonstrated the need for learners to have controls to limit learning to cater to their individual needs. Thus, the ninth pedagogical assumption is suitable for this learning model and remains as:

Personalised learning also needs to include the means to limit learning.

6.2.10 Learning model overall evaluation

The outcome of the usability testing has demonstrated that persistent access to support and collaboration with more capable peers is one means for novice learners to learn visual literacy decoding skills from visuals encountered in their everyday environment. The learning model has described how this can be achieved, which has had each of its pedagogical assumptions validated or refined using the results. Community and collaboration provide the learning material and learning support required. To access this support so that contingent encounters can be learning opportunities, learners need ubiquitous, context-aware, and personalised access to community and collaboration. Contingent encounters with visuals, either noticed by learners or highlighted for them, provide the visual examples to trigger learning. Learning occurs through imparting and receiving others visual analyses. Contingent encounters and their associated analysis are drawn from and added to the community.

6.3 Towards a Revised Prototype

The discussion of the prototype app is divided in two sections. The first section explores if the prototype app is indeed an appropriate answer to RQ2: *How can the learning model be implemented as a smartphone app?* The second section then addresses the usability issues raised in Chapter 5, Section 5.3.

6.3.1 Prototype overall evaluation

The participants received the prototype app well, appreciating its value and expressing a desire for the app (Section 5.3.1). More importantly, the participants all believed that they would learn from their environment using the app, which was the primary reason for its creation. Participants also believed that such an app would be fun to use and showed genuine excitement about the prospect of what they perceived as a social media take on learning visual literacy skills. Further, without being asked, over half the participants commented they would like to download and use the app if it were available. The fact that participants went 'off script' to specifically ask for the app was promising and demonstrated a real desire for such an app. This desire also aligns with the researcher's educated hunch that prompted this research; visual practitioners use the visuals surrounding them to learn and practice. The positive responses from participants and their desire for the app confirmed that the prototype meets the aim of this research, i.e. to leverage the visuals we encounter everyday as opportunities for learning visual literacy.

Participants liked the app's similarity to social media, perceiving it not only as a source of learning, but also as a source of entertainment. Two of participants noted that it did not feel like traditional learning, situating the app as some form of edutainment (educational entertainment). They were excited by the edutainment prospect, as they believed it would encourage their learning (Section 5.3.1). Perhaps the most interesting result came from one participant who wanted to use the app like they would a social media platform, but had no interest in pursuing further visual literacy studies. This participant understood the app was focused on learning, but believed there was potential for the app to focus on social interactions as a form of entertainment. This appears a common facet of m-learning, as noted by Crescente and Lee (2011), who included entertainment as a facet of m-learning. While the results demonstrated how engaging such an educational system can be, this also raises a caution that there is potential for social loafing. The prototype app provided tools for the community to self-moderate, which would help to keep interactions germane to learning. However, if these measures proved ineffective, the app would need to consider appointing moderators with the mandate to keep interactions focused on learning. Chen, Xu, and Whinston (2011) claimed moderation is an appropriate strategy, as moderators can be used as filters to improve the quality of information and help incentivise the production of useful information.

6.3.2 Usability issues and additional features

While the results were positive in confirming the prototype app as an appropriate practical outcome of implementing the tentative learning model, they also revealed new knowledge and demonstrated a potential for refinement of the prototype app. As the creative synthesis phase of heuristic inquiry requires the output to embody all the knowledge that is uncovered by the research (see Section 3.4.2 for further detail), a further iteration of the prototype app was required to account for the new knowledge uncovered by the usability testing session's results. The outcome of this second iteration of the prototype is referred to as the high-fidelity prototype throughout this research. The fidelity of the prototype was increased in the second iteration as correcting usability issues encountered required a higher fidelity (such as a legibility issue discussed in the next paragraph). The increased fidelity also allowed for the high-fidelity prototype to establish some of the front-end required for a future release candidate of the app. The high-fidelity prototype can be viewed at http://eyesup.mattyg.org/, and instructions for best viewing experience can be found in Appendix E.

Scenario 1's onboarding event revealed issues with legibility due to the size of text being too small (Section 5.3.2). This was easily fixed by increasing the size of the font. This issue resulted from the low-fidelity prototyping process, which utilised still images that could not scale text to fit the test device used during usability testing. The same issue does not occur in the high-fidelity prototype, as it uses Bootstrap 3, a standardised front-end framework for developing responsive mobile first experiences. Bootstrap 3's framework is designed to scale and reorganise an app's content based on the screen size it is displayed on. Therefore, any legibility issues are solved by using Bootstrap 3 in the creation of the high-fidelity prototype, as text elements default behaviour will be to scale to an appropriate size for the device screen it is displayed on.

During this onboarding and creating a new post scenarios, participants commented that they wanted to find friends from other social networks, and that they would like to share content with these networks. The participants' desire for these features is understandable, as the app draws on existing social media paradigms where these features are common place. However, while these features may provide benefits, they may also invite problems. Section 6.3.1 noted that there is potential for social loafing to occur which would distract the community from learning. As other social networks are not specifically designed for learning as the learning model describes, connecting to such social networks may potentially distract from interactions that are germane to learning. If this app were to be made live, these features would be added in a later release and monitored to determine if their inclusion is positive. Under the system the low-fidelity prototype proposes, users would still be able to follow friends, they would just need to know the username they have registered.

The app provided three views (see, map, and list) that a user may select from to see posts in their proximity. When launched, the app would open to the "see" view by default. However, participants found the "list" view to be the most useful, and was also the most frequently used in testing. Therefore, the default opening view was changed from the "see" view to the "list" view (Figure 5-1).

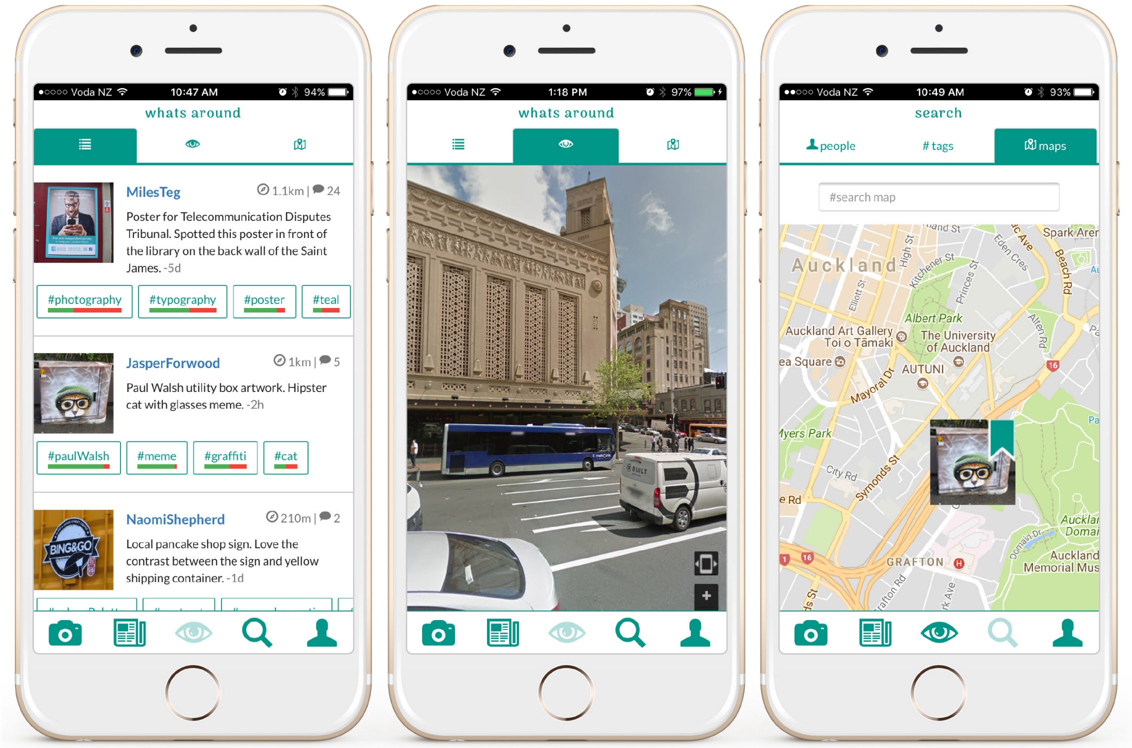


Figure 6-1: The "list" (left), "see" (middle), and "map" (right) view of the high-fidelity prototype. Author's original composition.

The "map" view was criticised for not including the bookmark status of posts. The participants wanted to see what posts they had already seen and liked. This raised two levels of feedback on posts that needed to be included. The first was about providing feedback to indicate if a post had been bookmarked. The second was about providing feedback to indicate if the post had been interacted with. The first level was fixed by including a bookmark icon to visually signal that a post is bookmarked (Figure 6-1). The second level may be addressed through any like or dislike status of the tags. By having tags coloured to show how a user has previously liked or disliked a tag gives feedback that they have previously interacted with a specific post and it's visual. This is not demonstrated in the high-fidelity prototype, as it is beyond the technical capabilities of the high-fidelity prototype.

The most significant usability problems encountered were related to the tagging, liking/disliking, and the commenting system. To comment on a post, a user first had to like or dislike a tag. The like/dislike status was then shown alongside the comment. The system was intended to help focus discussion within the community, as each comment would be accompanied by a polarised list of the community's understanding of the strengths and weaknesses of a visual. The system was confusing as participants tried to comment, only to find they could not as they had yet to like or dislike a tag. The participants' behaviours appeared to be a carry-over from other social networks, where one can post without any prerequisites. This makes the prototype app function in a different manner to what most users of social media would be used to. A potential solution would be to remove the need to like or dislike a tag. However, participants both liked and perceived value in liking tags before commenting. One participant suggested that the ability to comment should be hidden until a tag is liked or disliked. However, the results of scenarios involving upvoting and commenting showed that hiding interface elements may cause confusion, and so this cannot be considered an appropriate solution. Instead, the high-fidelity prototype greys commenting out with a message "like or dislike a tag to enable commenting", to address this issue (Figure 6-2).

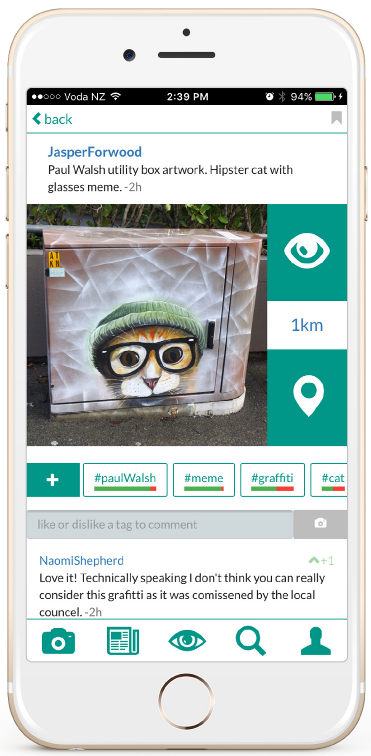


Figure 6-2: An example of a post in the high-fidelity prototype. Author's original composition.

Initially, tapping on a comment to display the up-vote, down-vote, and reply options was confusing for some participants. This was due to these buttons being hidden until a post was tapped on (Figure 5-2). To use such a system required prior knowledge of this behaviour, and therefore was introduced as part of the onboarding experience within the first scenario. The onboarding strategy did not appear to work for all the participants, as some rushed through the onboarding process. While it could be argued that the participant's lack of understanding on how to up-vote, down-vote, and reply was their mistake for not paying attention during onboarding, an interface should aim to be self-explanatory. Therefore, this usability issue was solved by including the options under each post as persistent interface elements (Figure 6-3).

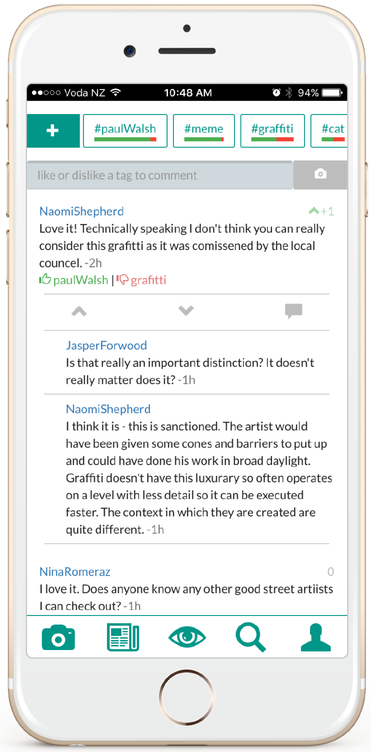


Figure 6-3: The comment structure on a post within the high-fidelity prototype. Author's original composition.

Participants mistook the tags associated with posts as buttons for liking or disliking a tag or comment (Figure 5-3). The error in mistaking tags for buttons appears to be a result of the elements being both isolated and backed with a colour, which gave them a button-like appearance. The solution was to include tags at the end of each post as part of the text, such as those onTwitter or Facebook (Figure 6-3).

A scenario that caused significant confusion was when participants were asked to follow a tag. Testing showed the options to follow tags were buried too deep in the apps interface, requiring participants to open their profile, then settings, then their tag settings (Section 5.3.5). Participants expected to be able to follow tags from the 'search tags' screen. The solution was to provide them with this ability, and one can now follow tags from the search page (Figure 6-5). Also, users mistook a tag icon next to their own profile name as a means of accessing tag options. This icon was intended to signify a user's name using a name tag icon, but only served to cause confusion. This icon served no purpose beyond aesthetics, so was subsequently removed.

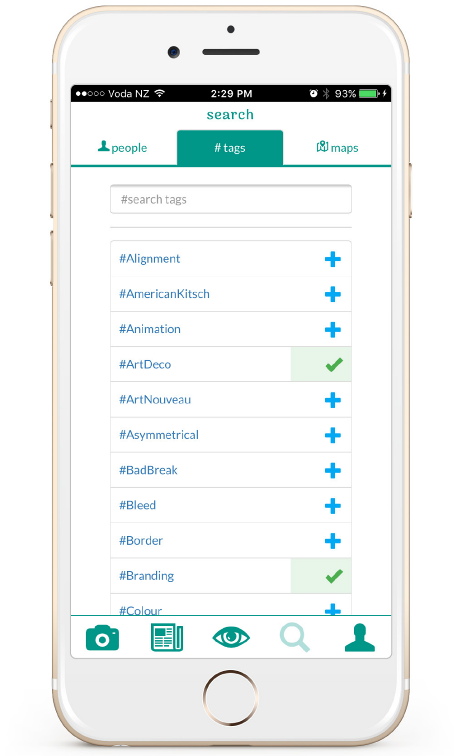


Figure 6-4: The search by tags screen in the high-fidelity prototype demonstrating how tags can now be followed. Author's original composition.

The search interface also had a problem with the spacing of elements. The search box had no gutter to separate it from the tabs below (Figure 5-7). This made it difficult to accurately tap on the elements. This was fixed by including a gap between the tabs and text entry field, reducing the chance of missed hits as the elements are now physically separated (Figure 6-4).

Participants also expressed a desire for seeing posts that are 'good', 'bad', or 'controversial' (Section 5.3.11). As the desire to filter based on 'good', 'bad', or 'controversial' posts appeared to be a motivational factor (Section 6.2.1), these were added as filter options to the search results of tags (Figure 6-5). These filter options allow users to search for a tag, then refine the results to show posts in which that searched tag is predominately liked, or predominately disliked. A third filter option is also included to show only posts that the like/dislike status is contested by users, i.e. an approximately even amount of likes and dislikes.

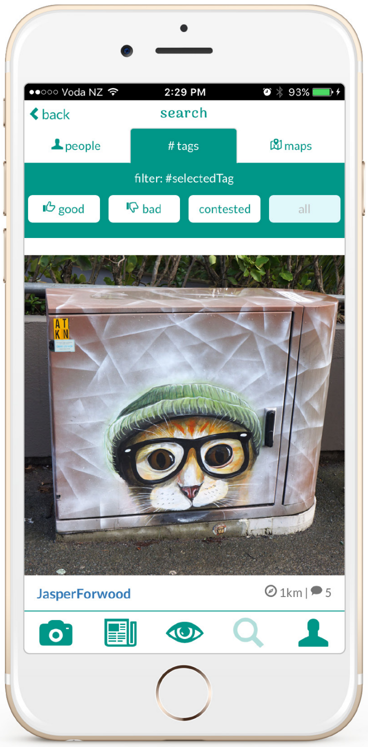


Figure 6-5: Screen following a tag search demonstrating how results can be filtered based on their like status. Author's original composition.

Two participants thought they would end up back at the news feed with their own post at the top after posting a new item, rather than be directed to their profile page. This is the standard behaviour of Facebook and other such social networks. Therefore, the high-fidelity prototype was modified to also exhibit this behaviour, so that users do not have to relearn different behaviours from what they may be accustomed to with other social media experiences.

Participants expressed a desire for photo filters on posts. This is a common feature on social media platforms and messaging apps. The desire for photo filters echoes a desire noted in the preceding section (Section 6.3.1), that some participants wanted to use the app as a social network for entertainment purposes. However, this research proposes that the purpose of photos in the app is to document visuals. Filters would interfere with this documentation process, as the photo would be a less accurate representation of the visual captured. For example, a logo that uses bright colours could be filtered to be black and white, obscuring the visual characteristics of the logo. Additionally, the inclusion of photo filters would create interactions that are not germane to learning and distract the purpose of the learning community. Therefore, while participants wanted photo filter features, they were not included in the high-fidelity prototype.

Participants felt that the news feed could be improved by changing how comments or replies are displayed. One participant asked if these items in the news feed could be limited to just a reply or comment, removing the content of the post they come from. While technically possible, this would remove the context of the original comment. The result would be like listening to only one side of a phone conversation, and the news feed would become incoherent. However, this is not to argue that the current news feed is fully functional; given the results, there appeared to be issues with coherency regarding comments and replies in it. To fix this, a well proven system was substituted based on Facebook's news feed. The original post is contained in a box with the caption, with the new comment or reply contained below. Now every news feed item contains an image and creates some hierarchal structure for showing what is a post, what is a comment on a post, and what is a reply to a comment on a post (Figure 6-6). This also solved another problem raised regarding the news feed; that the news feed was not visual enough. As the original post is now always included, every activity includes the original post's image, ensuring that the news feed stays highly visual. This also had the added benefit that any user familiar with Facebook would instantly understand the news feed.

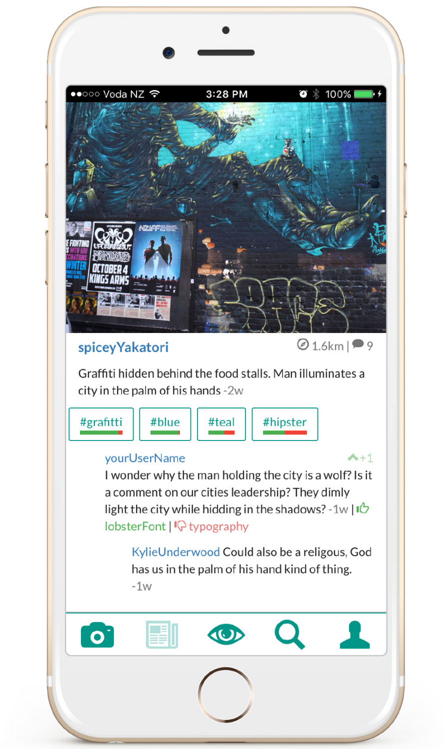


Figure 6-6: An example of a reply to a comment on the high-fidelity prototype's news feed screen. Author's original composition.

6.4 Restablishing the Connections

RQ2 asks, *how can the learning model be implemented as a smartphone app?* The learning model was used to create the prototypes of a smartphone app, however, this was not achieved through a direct translation. Rather, UCD methods were utilised as an intermediary between the learning model and prototype. This has created a degree of separation between the app and learning model in its reporting. As described in section 3.2, this was necessary to follow best practice in app development. This is not to say the app has deviated from the learning model, but rather to acknowledge a process of abstraction and interpretation has occurred. Therefore, this section reaffirms the connection between the refined learning model and high-fidelity prototype. Provided in the following table (table 6-1) is each pedagogical assumption matched to the high-fidelity prototype's features.

	Pedagogical assumptions	**Associated app feature/s**
1	Conducting visual analysis of noteworthy examples of visual communication within a learner's environment provides a means for learners to more deeply engage with visuals and learn from them.	The majority of the apps features involve interacting with "posts" which are the nexus point of the app's community and content. A post provides a noteworthy visual as a photo and as a location in a user's environment so that it can be experienced in person. The post's tag system provides a quick means to engage with visual analysis, while the comment threads provide the opportunity for more detailed analysis and subsequent discussion of that analysis. The creation of a post and the following interactions provide a means of engagement and learning.
2	Learners must impart and be receptive to different understandings of visual literacy.	The exchange of ideas occurs through creating posts, tags, liking/disliking tags, commenting, up-voting/down-voting comments, and replying to comments. These features are open to all users on all posts, allowing users with potentially differing ideas to impart and receive ideas. The tag, like/dislike, and then comment system is designed to focus potentially contentious discussions on the visuals within the post. The "shuffle mode" in settings (on by default) provides proximity notifications regarding posts that are outside the users defined following settings. This exposes the user to a variety of different visuals and their associated user comments.
3	Learning visual literacy is a collaborative activity.	The app's content is generated collaboratively through posting, commenting, and tagging. The associated like/dislike and up-vote/down-vote features allow the community to self-moderate and make value judgements on what is "good" or "bad".

3a	Provide a community that uses gamification mechanics to encourage collaborative learning.	Gamification has been included using several features: • Badges to encourage users to contribute to the community. • Point scoring mechanisms in the form of like/dislike and up-vote/down-vote. • Social feedback loops in the form of notifications. • Onboarding.
3b	Make learners aware of social factors, relating to their own activities, friends, interests, and location.	The app uses push notifications when the user is not engaged with the app to alert users to social factors. When using the app, badge notifications alert users to any social factors they have not previously seen.
3c	The learning community should be decentralised.	All the content within the app is user-generated. Users may add their own posts, comments, replies on comments, and tags. The community has autonomy to make value judgements of posts using the like/dislike tag system and comments using the up-vote/down-vote system.
4	Learning is triggered by contingent encounters with examples of visual communication in a learner's environment**.**	The app encourages contingent encounters with examples of visual communication in a learners environment in two ways: • The ability to create posts of encountered visuals provides impetus for users to be on the lookout for examples of visual communication in their environment. • Posts displayed through highlighting mechanisms such as notifications and the "what's around" views are contingent based on the user's location, shuffle mode preferences, and notification preferences.
5	Learners need to examine and investigate their environment's examples of visual communication as a means of learning.	Examining one's environment for examples of visual communication can occur through unaided and aided means in the app. The unaided means are: • The ability to create a post provides some impetus to examine ones environment for examples of visual communication to add to the community. Aided means are: • The three "what's around" views: "see", "list", and "map". These display posts in the user's proximity to explore. • The search features allow users to explore visuals posted relating to specific tags, other users, and locations.

6	Provide a means to highlight or direct learners to examples of visual communication.	The highlighting features of the app can be divided into active and passive features. The active features are: • The newsfeed, which displays a list of posts the user may be interested in. • The three "what's around" views, "see", "list", and "map", which display posts in the user's proximity. The passive highlighting features (highlights provided while the user is not actively engaged with the app) are: • Proximity notifications that highlight a post in the user's proximity based on their preferences. • Notifications regarding social factors.
7	Provide ubiquitous access to learning support.	This was addressed by creating a smartphone app. Smartphones are usually on the owner's person or in their immediate proximity, which would allow for potentially anytime and anywhere access to the app. The cellular and WIFI connectivity of smartphones would allow for ubiquitous access to the app's learning community.
8	Provide context-aware learning.	The app uses geo-locational data to provide a context aware learning experience. Information is organised based on location, which manifests in several ways: • Augmented reality experiences. • Interactive maps. • Lists of posts organised based on proximity to user. • Proximity notifications.
9	Learning needs the ability to be personalised to accommodate a learner's environment, goals, interests, and preferences.	The settings page provides multiple levels of control over: • Proximity notifications. • Update notifications. • Following a location or "home base". • "Shuffle mode" settings for receiving proximity notifications on posts outside of a user's defined preferences. The profile and search pages provide control over: • Followed users. • Followed tags.

9a	Personalised learning also needs to include the means to limit learning.	The settings page provides multiple levels of control to limit proximity notifications. This includes: • Turning proximity notifications off for followed tags, followed users, or all proximity notifications. • Setting the number of daily proximity notifications. • Setting the physical proximity to posts before triggering a notification. The settings page provides multiple levels of control to limit update notifications. This includes: • Turning update notifications off for followed tags, followed users, bookmarked posts, and comment replies. • Turning off notifications for home base.

Table 6-1: A table comparing the high-fidelity prototype's features to the refined learning model's pedagogical assumptions.

6.5 Chapter Summary

This chapter has discussed the learning model and prototype app, connecting each to existing scholarship. This study's test results further explores the aim of this research, that is how the visuals one encounters every day can be leveraged as opportunities for learning visual literacy. The discussion argued that the learning model and prototype app created by this study provides a means to learn visual literacy from one's environment.

The discussion of the learning model addresses RQ1: *How can everyday encounters with visuals be leveraged as visual literacy learning opportunities by providing learning support?* Throughout the discussion, the underlying pedagogical assumptions of the learning model are compared to the results, which either demonstrated the pedagogical assumption as purposeful or provided evidence that refinements were required and what these may be. These confirmed and refined pedagogical assumptions from the refined learning model. This refined learning model provides a detailed description of how to provide support so that everyday encounters with visuals may be leveraged as visual literacy learning opportunities.

The prototype app discussion focuses on RQ2: *How can the learning model be implemented as a smartphone app?* The outcome is the high-fidelity prototype app. The prototype app, when tested, was perceived as a fun and engaging visual learning means by the participants. This positive response appears to stem from the participants making positive correlations between the prototype and aspects they liked about social media and mobile games. Therefore, there are strong indications that the app proposed by the prototype would meet the aim of this research to leverage contingent encounters with visuals as opportunities for learning visual literacy.

Chapter 7: Conclusion

7.1 Introduction

This study has served as an investigation into learning the visual literacy skills of reading (decoding or understanding) visuals. The aim of this study has been to explore how the visuals we encounter every day can be leveraged as opportunities for learning visual literacy. The research operated on two presuppositions. First, that visuals are ubiquitous (Lester, 2011; Story, 2007), and second, one can learn visual literacy skills from analysing visuals (Stokes, 2002). Together, these presuppositions raised a line of inquiry pivotal to this research; if the visuals we encounter every day can be leveraged as visual literacy learning opportunities by practicing analysis, then the learners' everyday environments can potentially become visual learning environments. This research postulated that m-learning's anytime and anywhere learning capabilities would provide learning support in informal settings in which it has traditionally been unavailable. To explore the research aim, a learning model was synthesised from m-learning, visual analysis as a means of learning, constructivism, collaborative learning, rhizomatic learning, and the researcher's tacit knowledge were all incorporated. This was followed by a practice-based component that implemented user-centred design methods to prototype an app based on the learning model. The learning model and prototype app were then tested to validate and refine them. The outcome was two key contributions to knowledge, i.e. the refined learning model, and the high-fidelity prototype.

This chapter concludes the research. First, this research's outcomes and findings are summarised to provide answers to the research questions. Finally, the wider implications, limitations, and recommendations for future research are offered to conclude the thesis.

7.2 Contributions to knowledge

The aim of this study has been to:

> **Explore how the visuals one encounters everyday can be leveraged as opportunities for learning visual literacy.**

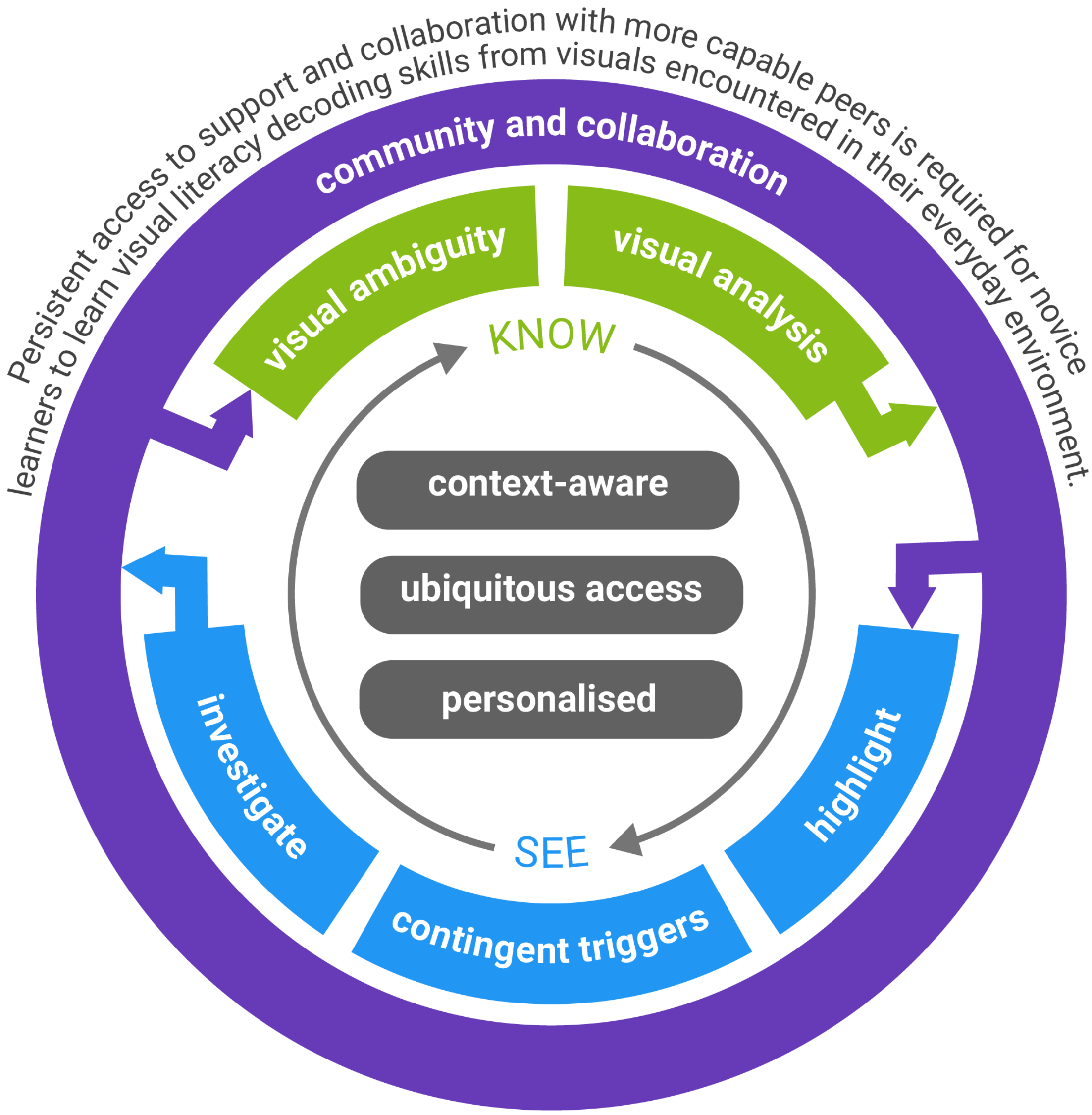
This aim was addressed using the two following research questions:

> **RQ1. How can everyday encounters with visuals be leveraged as visual literacy learning opportunities by providing learning support?**
>
> **RQ2. How can the learning model be implemented as a smartphone app?**

The exploration of the two research questions resulted in two key contributions to knowledge, each of which provided an answer to their associated research question. The first contribution is a learning model which was created while exploring RQ1. The second contribution is a prototype for an app that implements the learning model that sought to provide an answer to RQ2. Further to the learning model and prototype, the findings and their discussion (Chapter's 5 and 6) uncovered knowledge that informs the wider field of visual learning. These contributions to the field of visual learning are summarised last.

7.2.1 Refined learning model

This section presents this study's outcome for RQ1. *How can everyday encounters with visuals be leveraged as visual literacy learning opportunities by providing learning support?* The answer is provided in the form of a learning model. The refined learning model describes how everyday encounters with visuals can be leveraged as visual literacy learning opportunities by providing learning support.



Community and collaboration: learning visual literacy is a collaborative activity.

- Provide a community that uses gamification mechanics to encourage collaborative learning.
- Make learners aware of social factors, relating to their own activities, friends, interests, and location.
- The learning community should be decentralised.

Visual analysis: Conducting visual analysis of noteworthy examples of visual communication within a learner's environment provides a means for learners to more deeply engage with visuals and learn from them.

Visual ambiguity: Learners must impart and be receptive to different understandings of visual literacy.

Highlight: Provide a means to highlight or direct learners to examples of visual communication.

Contingent triggers: Learning is triggered by contingent encounters with examples of visual communication in a learner's environment.

Investigate: Learners need to examine and investigate their environment's examples of visual communication as a means of learning.

Context-aware: Provide context-aware learning.

Ubiquitous access: Provide ubiquitous access to learning support.

Personalised: Learning needs the ability to be personalised to accommodate a learner's environment, goals, interests, and preferences.

- Personalised learning also needs to include the means to limit learning.

Figure 7-1: Refined learning model. Author's original composition.

The overarching pedagogical assumption of the learning model is that persistent access to support and collaboration with more capable peers is required for novice learners to learn visual literacy decoding skills from visuals encountered in their everyday environment. This is supported by nine pedagogical assumptions and their sub-points. The learning model has been visualised to help demonstrate how the pedagogical assumptions may work together (Figure 7-1). The purple outer ring of Figure 7-1 represents the community and collaborative aspects of the learning model. The findings of this research show that community and collaboration provide the learning material and learning support required for novices to learn from their environment. Given the importance of community and collaboration in making the learning style proposed by the learning model effective, they are depicted as encompassing all the pedagogical assumptions.

The next ring, containing green and blue elements, describes the pedagogical assumptions that relate to an individual learner's circular reference system of visual literacy learning. The green elements associate to the *know* domain of the circular reference system. The blue elements associate to the *select* and *perceive* domain, summarised as *see.* The two aspects *know* and *see*, are of importance as they represent two common entry points into visual literacy learning (see Figure 1-2 in Section 1.4). They begin the process of internalising lessons from the community. *Know* and *see* are a reconceptualisation of Piaget's ideas of assimilation and accommodation (Sections 1.4 and 2.4.1). Unlike Figure 1-2 however, which focuses on an individual *receiving support*, the learning model also considers an individual *providing support* back to other learners in community by either contributing visuals or adding to a visual's analysis. The arrows show this flow of providing and receiving support as both knowledge and seen visuals move between an individual learner and the learning community.

Lastly, the grey innermost boxes contain the pedagogical assumptions relating to an individual learner and their unique circumstances and environment. As visuals are a ubiquitous resource in a learner's environment (Sections 1.1 and 6.2.4), ubiquitous access to learning support needs to be provided so that learners can leverage contingent encounters with visuals as learning opportunities (Sections 2.2.3 and 6.2.4). Context-aware learning also needs to be provided so that it can account for a learner's unique environment. This allows learning to dynamically change to reflect the circumstances or conditions that surround a learner (Sections 2.2.3 and 6.2.8) so that contingent encounters may be leveraged. Personalised learning takes account of a learner's goals, interests, and preferences so learning may conform to each individual learner's circumstances and environment (Sections 2.2.6 and 6.2.9).

Personalised learning also plays a role in limiting learning, so that a learner is not overwhelmed by the near limitless visuals in their environment that may be proposed for learning.

7.2.2 High-fidelity prototype

This section presents this study's outcome for RQ2. *How can the learning model be implemented as a smartphone app?* The high-fidelity prototype is the second iteration of the prototype and forms the final thesis of this research. The high-fidelity prototype provides a contextualisation of the refined learning model to demonstrate one means of achieving the learning model. Table 6-1 provides a summary of the high fidelity prototypes features and how they relate to the learning models pedagogical assumptions. The high-fidelity prototype can be viewed at *http://eyesup.mattyg.org/*, and instructions for the best viewing experience can be found in Appendix E.

Figure 7-2: A QR code that provides a link to the high-fidelity prototype. See Appendix E for instructions for best viewing experience. Author's original composition.

This research has demonstrated that the prototype app would meet the aim of this research to leverage contingent encounters with visuals as opportunities for learning visual literacy. The prototype uses features commonly found in social media and mobile games to provide a learning experience that is fun and engaging. Further, the research found that visual practitioners believed that paying attention to visuals in their environment is an important part of their professional practice. Consequently, an app that could aid with this professional practice was also perceived as beneficial by test participants.

The high-fidelity app demonstrates how users can capture and share visuals as posts with the app's community. Shared visuals can then be collaboratively analysed as a learning means. Each post is geo-located in a physical environment, so that users can view the visual both within an online community and in a real world environment. The use of geo-location allows for learning to occur when users are experiencing different levels of engagement. Users who are engaged can use the app to seek out visuals in their surroundings. Users who are not engaged may be sent push notifications to alert them of visuals in their proximity that they may be interested in. The app uses a community generated tag system, whereby users can tag posts. Each tag can be liked or disliked, which allows for a fast critique of visuals. Comments made on posts show the like status of the commenter, providing a context and focus to comments made.

7.2.3 Visual learning

Most of this study's findings inform the refined learning model and high-fidelity prototype presented in the preceding sections. However, some of the findings are applicable to the wider field of visual literacy and its learning. These are summarised as follows.

This research has connected existing pedagogical theory to the idea that individuals can learn and practice visual literacy skills by examining their environments for examples of visual communication to analyse. Constructivism and its learning and teaching practices, particularly explorative learning, were identified as a pedagogically matching learning visual literacy from one's environment. In providing evidence of these connections, this research has contributed to the body of knowledge regarding constructivist pedagogies' application to visual literacy, and opens pathways for other researchers to further explore this idea. This research also found that learners may perceive the learning embodied by the app and learning model positively, as they believe that examining and analysing visuals in their environment is a positive habit to form and something expected of them as visual communicators (see Sections 6.2.4, 6.2.5, and 6.2.6). A caveat was identified however, that the study concluded that the learning embodied by the app and learning model likely requires some prior knowledge or support for learning to occur in novices (Section 6.2.3 and 6.2.4). This may also explain why visual literacy must be learned, and why novice learners do not learn visual literacy merely as a result of exposure to visual communication, as noted in the scholarship of Avgerinou and Pettersson (2011), Spalter and Van Dam (2008), and Brumberger (2011).

Lester (2011), Barnes (2011), Gombrich (1982), Velders et al. (2007), and Stokes (2002) purport that visual literacy can be learned through the analysis of images. The results of this research show that learners also believe this. In addition, this research has uncovered that learners in this study believed visual analysis is not only something to be done as part of their learning, but as something important they must do as part of their ongoing professional practice.

The results show that analysing exemplary or poor examples of visual communication, with a greater preference for poor, is fun and engaging for learners, and may be leveraged as a motivator in learning. This research connects learner's analysing exemplary or poor examples of visual communication to social comparison theory, specifically Festinger's (1954) notion of upwards and downwards comparisons. Upwards comparisons can have a positive or negative effect on a learner's perception of themselves, while downwards can only have a positive. This research does not report a full understanding of this phenomenon as it was outside the scope of this research, however, this previously overlooked connection opens pathways for further research (continued in Section 6.5).

The app based learning proposed by this research appeared to be appealing to Millennials. The research came to similar conclusions to Gikas and Grant (2013) and Cheong et al. (2012), that learners were excited about the prospect of learning in a collaborative social media setting, and that the social elements of the learning model may appeal to Millennials because of their exposure to social media. However, two important caveats were identified. The first is that some form of formal learning is most likely required as a corequisite or prerequisite, which is a similar conclusion drawn by Crescente and Lee (2011) regarding m-learning. The second caveat is that of hygiene factors. Learners in this study had a minimum expectation of personalisation and preference options. Where earlier research has shown these attributes to be motivators (Fazey & Fazey, 2001; Ghauth & Abdullah 2010), the findings of this study suggests that Millennials' exposure to social media has resulted in personalisation and preference options becoming expected features that do not so much motivate learners, but rather cause dissatisfaction when absent.

7.3 Implications

Visuals are an important medium for communication today, placing pressure on the average person to understand and use visuals to fully participate in the contemporary world (Marcum, 2002; Tertiary Education Commission, 2008; Hanifan, 2008). Thus, scholars have stated a need for visual literacy and its learning (Arnheim, 1969; Spalter & Van Dam, 2008). The outcomes of this research address this need, by providing both a learning model and prototype app for visual literacy learning.

Arnheim (1969), Dondis (1973), and Bleed (2005) have all criticised academic programmes for failing to respond to their perceived need for visual literacy education. A significant implication of this study is that once a live version of the prototype app (or potentially any other application based on the learning model) is released, it will provide a visual literacy learning means that places little, if any, burden or onus on educators or their institutes. The rhizomatic and informal learning components included in the learning model and prototype allow learning communities to grow and organise themselves without the need for formal academic programmes or an educator's involvement. Therefore, this study's outcomes shift some of the onus of visual literacy learning away from academic programmes, rather than continue to criticise them for not catering to visual literacy and its learning.

The results demonstrated prior experience is likely to be required for learning from visual analysis. Thus, for the learning means proposed by this study to be effective, it will likely need to follow or be accompanied by an individual's formal education. Consequently, it is unlikely that the learning means forwarded by this study will replace formal learning or the role of education professionals. The app proposed by this study would most likely act as a tool to support or engage learners already involved with visual literacy learning with visual analysis.

The learning style proposed by this study provides a means of visual literacy learning that has not been available to novice visual literacy learners. The learning method proposed by this research will allow visual literacy learners to use contingent learning encounters with visuals from their environments as learning opportunities. As novices, visual literacy learners require learning support in the form of imparted knowledge or highlighted visuals; contingent encounters with visuals can rarely be capitalised on as learning opportunities. The outcomes of this research describes how these contingent encounters can now be utilised for learning. Further, the style of visual learning proposed by this study is designed to allow for visual literacy acquisition to occur as a by-product of a learner's daily interaction with their environment, converting a learner's environment into a visual learning environment. This allows visual literacy acquisition to become part of a learners' daily life.

This study has tested m-learning and related concepts, re-confirming ideas of collaborative learning, contingent learning, situated learning, authentic learning, context-aware learning, ubiquitous learning, and informal learning. It has further demonstrated how these concepts may operate in an informal and rhizomatic learning environment. The findings of this study have also demonstrated how visuals and geo-located artefacts may be used as a means of engagement in m-learning.

The research has potential for commercial outcomes. The high-fidelity prototype provides designs for the user interface, user experience, and some initial front-end development that a live version of the app could be based on. The findings show clear indications that the participants liked the prototype app; many wanted the app to be fully realised so they may be able to use it. The rhizomatic elements mean the community has potential to scale exponentially, thus, in a best-case scenario such an app has the potential to reach many visual literacy learners and redefine the way visual literacy skills are learned.

7.4 Limitations

This research used heuristic inquiry. This methodology's ability to draw on tacit knowledge and intuition was appropriate given the researcher's personal experiences and proximity to the subject under investigation. However, for these same reasons, the research is potentially biased by the researcher's beliefs, values, and understandings. Also, this research's initial questions formed from the researcher's practice as an educator. While this is a recommended practice for heuristic inquiry (Bach, 2002; Sela-Smith, 2002; Moustakas 1990), these questions are formed from experiential knowledge and therefore open their answering to the researcher's personal bias. While the researcher attempted to eliminate these biases by drawing from existing scholarly knowledge and seeking to confirm the outcomes with visual literacy learners, this bias can never be entirely removed and so must be acknowledged. The bias exists as result of the researcher's experiences working and studying in fields of design, creative technologies, communication studies, and educational technology. Additionally, the use of tacit knowledge and intuition also limits the replicability of this research's practice-based component.

The perceptions of the participants included in this study are by no means representative of all visual literacy learners or all domains of visual literacy. The participants were all located within Auckland, New Zealand and all had just completed a course called Visual Communication at Auckland University of Technology (AUT). The background and level of students of this course were known to match the intended user base of the app and learning model, which helped ensure participants could answer questions relating to their prior experiences. However, while this course was known to have a large and diverse roll, and the participants' spoke of four degree programmes that they were enrolled in (Business, Arts, Design, and Communication Studies) the majority were enrolled in the Bachelor of Communication Studies as either their only degree or a conjoint degree which may have biased the results. For example, the discipline of communication studies draws on semiotics, which as a method for analysing visuals inherently places emphasis on the importance of visual analysis – this is evidenced in the primer books *Visual Communication* (Lester, 2011) and *An Introduction to Visual Communication* (Barnes, 2011). Therefore, it must be recognised that other visual literacy learners outside this degree, location, or university may have voiced differing opinions to those found in the results due to their differing location, culture, or educational experience.

This research has attempted to form a learning model that accommodates a variety of understandings and disciplines of visual literacy rather than enter a debate on which disciplines or theories are correct, especially regarding visual analysis. This can be seen as evidenced in the inclusion of the learning model's second pedagogical assumption that *learning must be inclusive of the different understandings of visual literacy*. However, there is a bias towards a Helmholtzian or constructivist view of visual perception (explained in Section 1.3). This bias is a result of recognising the role of memory in perception, which allowed for connections to be drawn between perception and social and cognitive constructivist learning theory. While this helped bridge the field of visual literacy to learning, it may preclude other understandings of visual perception, such as a Gibsonian ecological-direct view in which the role of memory is less clear as it limits itself only to information found in a visual (Norman, 2002). Therefore, this research must acknowledge that although it has attempted to develop learning that is not specific to any one understanding of visual literacy, there is potential for bias towards a constructivist understanding of visual literacy given this is what was used to form the connections between seeing and learning. These were then further used to create the tentative learning model.

Another limitation is that of time and money. This research noted that m-learning research is overly optimistic in its reporting and often claims technological implementation as a measure of success (section 1.5). This research has addressed this problem by focusing on pedagogy before technological implementation and sought feedback from visual literacy learners to potentially validate outcomes. However, while this approach showed strong indications that the learning model and associated app would provide a means to learn visual literacy skills, there is no way to truly know how they will operate until they can be fully implemented and then measured. As noted in section 6.2.3, the privacy issues raised also could not be addressed until planning around a live release is undertaken. A live version of the app would take significant funding and time beyond the scope of this PhD. A conservative quote estimated in excess of $100,000 (NZD) to build the app, and this cost does not include the augmented reality components, hosting, maintenance, legal, or advertising. To justify such expense, a business model would need to be developed to ensure this expense would be recouped. Also, if an app were to be built to release, it was rationalised that it would still take time to accumulate enough users to have an active community so that testing could take place. This time allowance could not be planned confidently within the time frame of this PhD.

7.5 Recommendations and Future Research

This research has shown learners positively perceive the learning embodied by the app and learning model reported in this study, however, the learning model and its application remain untested in a manner that measures gains in visual literacy. Therefore, the first recommendation for future research would be to launch a functional version of the prototype app and test its efficiency (how quickly knowledge is learned) and effectiveness (how long knowledge is retained) on learning visual literacy. This research identified that the implementation of the learning model would most likely need to accompany formal learning, therefore testing could occur as some intervention to support formal learning objectives. For example, the app could be trialled in half of a university course so that data on efficiency and effectiveness can be collected and compared against the half who did not use the app. Informal learning using the app could potentially be tested by comparing an individual's knowledge before and after use of the app for knowledge gains. For either test scenario to occur, a critical mass of users would need to be reached to both populate the app with content and ensure consistent activity among the user base to maintain engagement before any testing could take place. Planning around a functional release of the app would also allow for an exploration into how privacy issues could be addressed.

A functional version of the app would also open possibilities as a tool for data collection. Information such as preferences, imagery documented, time spent with the visuals, highlighting response rates, commenting, tagging, voting, interactions with a feature, all inputs, and meta-data can be collected for analysis. The backend of an app such as the prototype would use is essentially a database of tabular information that records all users' interactions. Such a database could be used to look for any patterns regarding visual literacy and its learning. For example, all comments expressing a desire for help could be analysed in an attempt to understand what visual literacy learners most frequently need help with when separated from traditional support. Another example would be to analyse the like and dislike activity on tags across the entire user base. This could be used to identify which type of visuals or features visuals learners find most engaging. Information such as that given in the two preceding examples could be used to improve the wider field of visual literacy learning and teaching activities by identifying areas learners voice a desire for help with and what aspects of visuals engage learners.

Further research could explore the effect of upwards and downwards comparison on learning gains. For example, this research noted that participants showed a preference for downward comparisons in the form of analysing poor examples of visual communication; however, does this translate to greater learning gains over upward comparisons made when analysing good examples? While downward comparisons may have a more positive effect on a learner's self-esteem over upward comparisons which risk negatively impacting a learner's self-esteem, which one nets the most learning gains? Can one type of comparison be favoured over the other or are both needed? Questions such as these on visual analysis as a learning means and social comparison theory provide interesting further paths for research that could inform visual literacy learning and teaching practice. Additionally, further research could explore social comparison theory outside the narrow scope of visual literacy learning for similar trends. Lastly, research could explore how upwards and downwards comparisons relate, if at all, to common teaching practices such as using examples and non-examples.

The prototype app may have uses beyond that of just learning visual literacy skills. Future research may consider other applications of the app, as either a learning tool for other fields, a means to socially construct knowledge, or as a geo-located social network. The app received attention and commentary from a wide range of people, all who viewed the application of the app to their own unique problems or desires. Suggestions for alternative uses included geologists learning about rock formations in the field, schools keeping track of monarch butterflies, and enabling architecture to be highlighted and discussed for architecture students. Future research could identify further such possibilities and how they relate to the learning model and app.

The pedagogical assumption regarding highlighting as a prompt to learn produced results that raised some interesting questions for further investigation. For example: *How many highlights should occur per day? Should the occurrence of highlighting change based on the learner's immediate environment or context? How many times should a visual be highlighted? How much time should pass before highlighting a visual again, if ever? What interaction with the community should occur on each highlight, if any? How long should each progressive interaction be?* Investigating these and associated questions on highlighting may uncover knowledge that can improve the efficiency and effectiveness of learning visual literacy skills from one's environment and inform visual literacy educational practices.

Likely technological advancements in the next five to ten years will open new possibilities for the application of the learning model in the field of wearable technology. In particular, mobile augmented reality headsets (mobile AR) have the potential to persistently overlay highlighting and additional information onto a user's field of vision. The app prototyped in this research requires several steps for highlighting to occur. First a notification alerts a user to check their mobile device, then open the app, and then see through the AR camera view. A mobile AR headset has potential to remove all these steps, as it could highlight any visual of interest that enters the wearer's field of vision. The implications of such learning in visual literacy are unknown. Two such headsets, Recon Jet and Epsom Moverio were experimented with during the early phases of this research to be rejected in favour of smartphones. The headsets lacked easy means for input and control, making for a poor user experience beyond simple and passive heads up display tasks. However, technology in this field is constantly improving, as evidenced by the recent release of the Microsoft HoloLens. With continual updates in the field of heads up displays and AR, there is a good chance a device will be released which will suit this learning model. If this is to occur, applying the learning model to mobile AR headsets could be used to help understand affordances such devices have regarding visual literacy learning.

The application of heuristic inquiry and UCD in this research was fitting due to the prior knowledge of the researcher and need to create an app. The outcome was a bespoke approach that merged the two methodologies with the aim of meeting this research's objectives. While heuristic inquiry is common in design research and UCD is a common industry practice, their application in educational research is uncommon. This blending of methodologies may be of use to other researchers, specifically those with experiential knowledge relating to their research problem and development skills. While other methodologies may provide more robust and proven approaches in areas with a beach-head established, the combination of heuristic inquiry and UCD allowed this research to forge its own. The combination of methodologies allowed the researcher to move forward with a problem encompassed by a dearth of scholarly knowledge.

7.6 Summary

In conclusion, this research has sought to explore how the visuals one encounters every day can be leveraged as opportunities for learning visual literacy through practice-based research. This research revealed that visuals in one's environment can be used as visual literacy learning opportunities provided there is learning support available. Consequently, this research pooled existing scholarship with the researcher's knowledge, and tested it with learners. The result is a learning model that describes how everyday visuals may be leveraged as visual literacy learning opportunities, and a prototype for an app that demonstrates this in practice. These outcomes must be understood for what they are, first steps towards understanding and implementing visual literacy learning from one environment in a manner previously beyond that of novice learners. Consequently, it is the hope of this researcher to see some of the ideas it proposes implemented by educators, and to see the learning model and app further advanced and refined.

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Appendix

Appendix A: Information Sheet

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Participant Information Sheet

Date Information Sheet Produced:

17/04/2016

Project Title

The more you know, the more you see.

An Invitation

My name is Matthew Guinibert, and I am conducting research for my PhD on how people learn visual literacy skills. As part of this research I will be collecting information a new app I am creating to learn visual literacy skills. I am interested on how people will use the app and their impressions of the app.

This study is voluntary and if you choose to participate you can withdraw up to a week after participating. If you wish to participate, please do get in touch. You will be offered a koha of $40 in petrol or food vouchers after the study to compensate you for your time.

I am conducting two rounds of testing separated by 3-6 months. I will need people for both times.

What is the purpose of this research?

This research has two goals. The first is to better understand how people can use their environment as an opportunity to learn visual literacy skills. The second goal is to develop a smartphone app to help learners with this.

How was I identified and why am I being invited to participate in this research?

You have been invited to this study as you are a student presently studying or have just studied Visual Communication at AUT. This research is interested in providing ways to help students learn some of the skills taught in this paper.

What will happen in this research?

This research will take between 40 minutes to an hour. It will involve you using a smartphone to test a new app that is currently being produced. You will be asked to try to complete tasks on the app to gauge how well the app works. You will also be asked about your experience with the app, and your experiences and perceptions with learning visual literacy skills. Your answers will be recorded.

What are the discomforts and risks?

There are no potential risks in this research and participation is optional.

How will these discomforts and risks be alleviated?

There should be no risk or discomfort. This study is voluntary and if you choose to participate you can withdraw up to a week after participating. All answers are also confidential.

What are the benefits?

This study benefits me as it is part of my PhD qualification. It benefits the wider community as it seeks to explore new and improved ways for people to learn visual literacy skills.

How will my privacy be protected?

This study will be recoded to document your answers. This recording in its unedited state will be kept confidential, only ever being seen by my supervisor and me. Any results published from this study will not include your name or any other information that could be used to identify you. Any visuals used from the recordings will blur you, so that you will not be identifiable.

What are the costs of participating in this research?

This study will take up to an hour of your time. As a way of compensating you for your time, a $40 koha of petrol or grocery vouchers will be offered.

What opportunity do I have to consider this invitation?

The first round of testing will need you to reply within two weeks. The second round of testing has a lead time of 3 months for you to consider this invitation.

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How do I agree to participate in this research?

You need to let me know you wish to participate in the study. You can contact me on matt.guinibert@aut.ac.nz. If you wish to participate, I will send you a copy of the consent form. I will provide some time before the study to answer any questions you have before agreeing to participate.

Will I receive feedback on the results of this research?

If you wish to receive the results of the study, they will be published at a future date. An option on the consent form will be available to indicate if you wish to be sent the results.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Petra Theunissen, petra.theunissen@aut.ac.nz, +64 9 921 9999 ext 7854.

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, Kate O'Connor, *ethics@aut.ac.nz* , 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Matthew Guinibert

matt.guinibert@aut.ac.nz

+64 9 921 9999 ext 8437

Project Supervisor Contact Details:

Dr Petra Theunissen

petra.theunissen@aut.ac.nz

+64 9 921 9999 ext 7854.

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Approved by the Auckland University of Technology Ethics Committee on 6/05/2016 AUTEC Reference number 16/156

Appendix B: Email invitation

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Email Invitation

Hi,

My name is Matthew Guinibert and I am inviting you to participate in a study about visual literacy. I need ten people, five next month and another five in roughly 2-4 months, to test out a new app I am developing and share their thoughts on learning visual literacy skills. The study is confidential and will require up to an hour of your time. You will be gifted either a $40 petrol or grocery voucher to compensate you for your time.

The full details can be found in the attached pdf to this email if you would like further details. If you are interested in participating, please respond by email before the 5th of August 2016 to me on matt.guinibert@aut.ac.nz to register your interest.

Best regards,

Matt

RESPONSE:

Hi xxx,

Thanks for responding. Your interest has been registered.

I will be randomly selecting 5 applicants after the 5th of August from all those who apply. If you are not selected for the first round you may still be selected for the second round of testing in a few months time. Also please know that even if you are selected, you do not have to participate and can withdraw from the study at any time.

Regards,
Matt

Appendix C: Consent Form

Consent Form

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Project title: ***The more you know, the more you see***

Project Supervisor: ***Dr Petra Theunissen***

Researcher: ***Matthew Guinibert***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 17/04/2016.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that notes will be taken during the session and that they will also be video-taped and transcribed.
- ○ I permit the researcher to use stills or clips from the video recordings in publications arising from this study in as long as my appearance is blurred so anyone viewing the stills or clips will be unable to identify me.
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If I withdraw, I understand that all relevant information including recordings and transcripts, or parts thereof, will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a summary of the research findings (please tick one): Yes○ No○

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

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Date:

Approved by the Auckland University of Technology Ethics Committee on 6/05/2016 AUTEC Reference number 16/156

Note: The Participant should retain a copy of this form.

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Appendix D: Indicative Tasks & Questions

User Testing Session 1: Tasks and Questions

TE WĀNANGA ARONUI
O TĀMAKI MAKAU RAU

Pre-Flight checklist...

- Welcome
- Have you read the information sheet? Provide a printed copy. Any questions?
- Sign consent x 2 – give one to participant.
- Introduce how the session will work. 3 sections. Warm up questions. User test. Interview.
    - Explain supplementary: The app is in very early stages – what we call wireframes. This is a rough draft. These try express features, but are not actually functional – the idea is to get feedback before vast amounts of energy and money are expended.
- Explain: there are no right or wrong answers – just be truthful. The point of the questions is to test the app, not you.
- Explain: recording equipment…
- Start recording.

Introduction:

1. Can you please tell me about your last experience learning the rules or ideas of visual communication? In particular the ones that helped you read, interpret, or understand images you see.
    a. Follow up to 1. - What did you do to better understand these rules or ideas outside of class?
    b. Follow up to 1.a - How did this work out? (was it helpful?)

2. Can you tell me about a time you noticed an image (billboard, sign, poster, etc.) you may have passed on the street and gave some thought to?
    a. Follow up to 2 - What thoughts went through your mind when you saw it?
    b. Follow up to 2.a - Did you learn anything by doing this?
    c. Follow up to 2.b - Do you think you could learn visual literacy skills by doing this?
    d. Follow up to 2.c - If so, do you do this presently? And if not, why don't you?

3. Can you tell me about any forums, tools, or communities where you do learn visual literacy outside of class?
    a. Follow up to 3 - What did you use these for?
    b. Follow up to 3.a – How effective did you find this learning?
    c. Follow up to 3.b – What specifically about this do you think lead to your learning?

User testing tasks:

Onboarding

The first task is designed to both introduce participants to the idea of the app and the limitations of the prototype. Data collected will be around how well this introduction works – I want users to feel comfortable with the app from the start.

TASK 1

Your visual communication lecturer has just told you about a new app that may help you practice what you are learning in class. The app is called Eyes Up and your lecturer suggests you check it out. Can you please open the app and create a new account.

(NOTE TO INTERVIEWER – SOME SCREENS DON'T WORK. Remember to ask what tags and people they would be interested in following…)

Follow up questions may include:

- Did you understand the introduction screens?
- Do you understand the purpose of the app from the introduction screens?
- Do you feel you understand enough to explore the app comfortably?
- Did you feel the settings make sense and serve some purpose in your learning? – What and Why?
- Do you have any suggestions to improve the experience? – I will ask this again after they have used the app more… Once users have experienced the app they may have a much better understanding of what could be explained better or what was missed.

Collaboration

Learning in this app is collaborative. It needs to make learners aware of other learner's actions, should be self-organising and moderating, inclusive.

Task 2a – See what is around you

You are waiting for a friend in a café who is running 10 minutes late. You decide to check the app (Eyes Up) to see if there is anything around you. Open the app and check if there are any posts close to you using the AR, List, and Map view.

- What view do you think is the most helpful? Can you explain why you think that?
- Would you use all views together or stick to one? Why?

Task 2b – see what is around/upvote/comment reply

You decide to check out one of the items that is around you and both up-vote and reply to a comment.

- What do you think the purpose of commenting is?
- What do you think the benefits of up -voting a comment would be?

Task 3 – Push notification/vote on tag

You are walking down the street on the way to university. Your phone beeps to let you know you have a notification. You check it out and vote on one of the items associated tags. <u>Note: only the photography tag is working.</u>

- Would you add your own tag to this?
- What button would you press to do so?
- What is the tag you would add? Why would you add that tag?

Task 4 – Follow a new tag

You are taking a new class and your lecturer tells you about grids. You decide to follow that tag as a way of seeing it in action. Navigate to your settings and follow a new tag that will help you learn about grids.

- Browse the other setting options. Do any stand out? Is anything missing you would expect?
- What other tags would you follow and why?

Task 5 – Create a new item

You are walking past a food stall and notice it has some interesting signage you want to share on Eyes Up. You are not too sure what that style would be called. Create a new post of this on Eyes Up. For all the entry fields, please state what you would enter (as these do not work).

- Would you want any prompts or suggestions to help you fill out the details? What and Why?
- Is there any additional information you would like to add but the interface didn't let you?

Task 6 – Check new activity

The Eyes Up app has a notification badge above it to let you know there has been activity on your account. You checked the app an hour ago so the notification must be recent. Open the app and see if there was any activity in the last hour that could account for the badge.

- Read the rest of the older notifications.
- Are there notifications of other events you would like to see? Why?

Task 7 – Search a place for signs

A friend is telling you about a sign they saw on Rutland St just off Queen St. Search the location and see if you can find this sign on the app Eyes Up.

- Is this process clear?
- Are there any other map based features you would like? Why?

Task 8 – Check out the latest posts you are following.

You are watching TV and the ads come on. You pull out your smartphone and decide to see what's happening on Eyes Up by checking out the latest posts and comments. Open an item from the news feed and book mark it.

- Navigate to your bookmarks and see what you have bookmarked.

Task 9 – Find a comment you made.

You disagreed with a comment a week ago and want to show it to your friend. Try to find a reply to a comment your account has made.

A couple of open-ended closing questions:

1. How do you feel about the type of learning that would occur on the app you just trialled:
   a. Do you think you would learn using the app? If so, how much? If not, why not?
2. How often would you engage with this app? How long each time? Why?
3. Do you have any suggestions or comments regarding the app you just trialled?
4. What do you think about the tag system?
   a. Would you vote on tags?
   b. How do you feel about needing to vote on tags before commenting?
5. How do you feel about the tagging system?
   a. How do you feel about liking and disliking individual tags? Why?
   b. How do you feel about needing to like/dislike a tag before you can comment, and that status being visible?
6. If you have a choice, how would *you* like to learn best about images?
7. Anything else you would like to add, ask or comment?

Part 2 - Indicative questions:

1. Do you think it would be beneficial to learn or practice visual literacy skills in a community of learners like the app would use?
    a. How would you view the information provided by others on the community?
    b. Would you share your own ideas?
    c. Would you try seeking sub communities or organising your own? What communities would you seek out or organise?

2. Have you ever seen a sign or image and thought, "wow that's good or bad"?
    a. Would you stop to share these on the app?
    b. Would you give your opinion? – Comment/like/vote
    c. How many times a month do you imagine you would do this?
    d. How could you be encouraged to do this more? Both with the app or some other way?

3. Do you learn when analysing (breaking down) images? (slight overlap on introduction question)
    a. Would you share your analysis?
    b. Would you comment on someone else's analysis if part of a community?
    c. Would you comment in disagreement with others?
    d. Would you seek help from the community to aid in your analysis of a visual?

4. If you were learning visual literacy skills from your environment in a collaborative setting (such as with the app), what kind of activities would you like to be notified about in regards to other learners/users actions or activities?
    a. Would you like to receiving notifications about:
        i. Other learners posting?
        ii. Comments agreeing with your tagging and voting (liking or disliking)?
        iii. Comments disagreeing with your tagging and voting (liking or disliking)?
        iv. Posts from tags you like?
        v. Posts from a location you can set?
        vi. Posts you happen to pass?
    b. How would you like to receive these notifications? How many? When?

5. Do you think your visual literacy skills would benefit from having images pointed out to you as you go about your day?
    a. Would you stop to look?
    b. How would this help your learning?
    c. Do you think this would this be intrusive?
    d. How many times would you expect this to happen each day?
    e. How long do you feel you would dedicate to checking out a visual? For example, 30 seconds, 1 minute, half an hour,...?
    f. Would you want to see others' interpretations/perceptions to what is being pointed out? How would you like to see these?
    g. Would you want to add your interpretations/perceptions to what is being pointed out? How would you like to add these?
    h. Would you like contextual information provided? If so, what?

6. The goal of the app is to provide visual learning that can be present everywhere:
    a. What would you perceive the benefits of this to be?
    b. What would you perceive the negatives of this to be?

7. If you were to engage in collaborative learning which uses the images around you, what would you want to be in control of? For example, would you want to control the members of your community or how much time you spend learning?
    a. What kind of personalisation or customisation options would you want?
    b. Would you want a means to limit how often or when learning occurs?

Appendix E: How to View the High-Fidelity Prototype

The research undertaken created a prototype of a smart phone app. A copy of this prototype may be accessed from the following link:

http://eyesup.mattyg.org/

For best viewing result, the link provided will need to be added to your home screen of your device to run in full screen mode. Please follow the instructions below

iPhone:
1) Open Safari on iPhone and load http://eyesup.mattyg.org/
2) At the bottom of the screen you will see an icon depicting an arrow coming out of a square. Tap this button.
3) This will open a dialogue box containing options. Tap "Add to Home Screen." You will be asked to choose a name for the homescreen icon – it will default to eyesUp which can be left as is.
4) Close Safari and open the eyesUp prototype from the eyesUp icon on your phones home screen.

Android:
1) Open Chrome on android and load http://eyesup.mattyg.org/
2) Tap the menu button.
3) Tap "Add to Home Screen." You will be asked to choose a name for the homescreen icon – it will default to eyesUp which can be left as is.
4) Close Chrome and open the eyesUp prototype from the eyesUp icon on your phones home screen.