



How Far is Up?

The Functional Properties and Aesthetic Materiality of Children's Storybook Applications

A project submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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HOW
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UP?



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Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

Signature

Betty Sargeant
February 2015

Abstract

This study centres on a project, a children's book application titled *How Far is Up?* This artefact is an interactive, narrative-based digital book containing written text, animation, video, audio narration, music and sound effects. Book applications have become a new format for the picture book. Printed picture books are used to teach children literary and social skills; they are cornerstone tools in early developmental education. Increasing numbers of children now read digital books and engage in literature via digital devices. Given the crucial educational and social role that picture books have played in Western cultures, it is timely that we investigate how this medium has changed due to digitisation. This research evaluates the design of book applications and the educational and social implications of remediating the picture book.

Theorists of children's literature and cognitive science suggest the need for a more comprehensive set of principles aimed at guiding book application designers. In particular, there are concerns relating to the design of interactive, animated activities within these artefacts. Evidence shows that these features may distract users from a story. Further to this, existing applications commonly contain an audio narrator who 'reads' the written text aloud. An adult is not required to read these items with a child. This is despite the clear educational and social benefits associated with shared reading.

My results demonstrate new insights, focused towards three main areas. Firstly, my findings show how designers can apply a counterpointed triad formed from typographic text, imagery and audio, alongside the alluring qualities of animated and interactive features, in order to form a richly described narrative environment. In presenting a refined level of visual movement, designers can direct users' attention towards narrative detail. Animated interactive activities may also help users to imaginatively engage in application content.

Secondly, as a result of deploying my counterpointed triad technique, whereby typographic text, imagery and audio each impart separate narrative messages, the narrator in *How Far is Up?* does not 'read' the written text; the narrator supplies additional story information. In order to comprehend this application's textual content, a pre-literate child will need to engage in shared reading. Participant studies show that young children can understand and enjoy the *How Far is Up?* story when they read the application independently. My findings also show that children enjoy reading this application together with an adult, and that this shared reading activity may invoke deeper narrative comprehension and it may support the formation of close social bonds. This application's design encourages intergenerational social interaction to occur over a shared mobile device.

Finally, this research uncovers connections between material practices and social and experiential activities. By extending the counterpointed triad technique, I form a connection between digital and physical environments; highlighting the ways in which functional and aesthetic practices can lead to usable artefacts existing in social and physical contexts.

This project contributes to the fields of digital humanities, education and human-computer interaction, and to the disciplines of interaction design, digital design and picture book design.

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1

Description of Project

This study centres on a project, a children's book application titled *How Far is Up?*¹ This artefact is an interactive, narrative-based digital book. It contains written text, animation, video, audio narration, music and sound effects. In this exegesis, I investigate the functional properties and aesthetic materiality of book applications. My aim is to contribute new knowledge applicable to the fields of digital humanities, education and human-computer interaction, and to the disciplines of interaction design, application design, digital design and picture book design.

How Far is Up? is a computer application. Applications are small software programs that are well suited to delivering high levels of media-rich, interactive content (McCoy and Kleinfeld in Wikert 2012). The term 'book application' operates as a sales category and it identifies a specific type of digital book, one that is designed for mobile devices. A book application may be described as being an ebook, in that it is an electronic, or digital, book. Yet a distinction can be drawn between how these two items function. I will argue that, "people *read* ebooks, whereas they *use* book apps" (Sargeant 2015). For the purposes of this research, I differentiate between the terms ebook and book application.

Book applications have emerged as a new picture book format (Yokota and Teale 2014, p. 577). Within Western cultures, picture books have historically played a crucial role in early childhood education (Yokota and Teale 2014, p. 578). It therefore seems pertinent to ascertain the ways that these items have been affected by digitisation. There is a need for research that improves our "conceptual understandings" of children's animated digital books that contain highly interactive content (Yokota and Teale 2014, p. 577). This project addresses this need.

¹ Applications are commonly known by the abbreviated term apps.

In chapter two of this exegesis, I provide a review of literature; I acknowledge existing research from the fields of children's literature, interaction design, game design and cognitive science, and I present a survey of existing children's book applications. Chapter three contains a detailed discussion of my theoretical framework. Chapter four features a case study analysis, and chapter five contains an analysis of my own creative work *How Far is Up?* Finally, chapter six concludes this exegesis; I make clear the new knowledge that has emerged as a result of this study. My findings address issues around: the relationship between textual, visual and audio content; the social and educational implications associated with sensory-rich, interactive storybooks; and the connections between digital media, arts practices, materials, and physical experiences.

1.1 THE CREATIVE PROJECT

A central aspect of this practice-based research is the children's book application *How Far is Up?* (as seen in Figure 1). This artefact features a fabricated, fictional story aimed at audiences aged four and five. In making this application, I have juxtaposed digitally crafted and handmade designs; I have also combined a comic fictional story with factual NASA data. My aim is to create a detailed, richly described, play-based, sensory experience in order to engage audiences in a literacy artefact.

When making *How Far is Up?* I have used a number of computational and arts-based practices. I have written and illustrated the story, constructed and photographed the visual settings, animated the imagery, composed and performed the music, performed the audio narration, created the typographic design, and programmed the interaction design.² I worked within the software suite *Demibooks Composer Pro* to apply rules and behaviours to each of the six hundred and twenty-seven assets that make up this work.³ When the computer executes my programmed instructions, these assets can move and change. These processes involve creating automated and interactive digital designs. In shaping this artefact's interactive features, I invite users to become active participants in the storytelling experience. Through interacting with this application users uncover story-related detail and can engage in experiential activities. The applied techniques used in this application are underpinned by practical and theoretical knowledge.

² My practice involves visual, rather than textual, programming; I do not write source code. My practice of programming may also be referred to as GUI (Graphic User Interface) programming or visual programming.

³ In this context, the assets are still graphics (including still frames associated with stop-motion animation sequences), audio, and video files.

Figure 1
Homepage: *How Far is Up?*
This artefact is a book application, a children's digital book designed for touchscreen tablets.



1.2 THE THEORETICAL APPROACH

This project revolves around a children's digital, literary artefact. As a consequence, my study is informed by research that addresses both children's literature and human-computer interaction. Some specialists in the broad area of children's literature focus on analysing picture books (Nikolajeva and Scott 2006; Nodelman 1988). Picture books can be defined as "books intended for young children which communicate information or tell stories through a series of many pictures combined with relatively slight texts or no texts at all" (Nodelman 1988, p. vii). Children's literary theorists Maria Nikolajeva and Carole Scott study the ways in which picture book authors and illustrators communicate stories through forming relationships between words and images (2006). I draw on this body of research to emphasise the ways in which book application designers can combine different media, and the effects that this can have on audiences.

I also focus on research derived from human-computer interaction studies. The field of human-computer interaction is made up of numerous disciplines, including interaction design, game design and cognitive science (Carroll 2014). Within this exegesis, I adopt a framework based on theories from interaction design and digital narrative scholar Janet Murray. Murray's research revolves around her theories on digital storytelling and the "affordances of the digital medium" (1997, 2012).

Ideas relating to affordances have become popular within the human-computer interaction community, as they can create "a *perceived* relationship between appearance and action" (Jung and Stolterman 2012, p. 648, emphasis in original). Yet the idea of affordances is an unsettled notion (Gaver 1991; Gibson 1982, 1979, 1977; McGrenere and Ho 2000; Norman 2004, 1990, 1988). According to Murray, the term "affordance" describes the "functional properties of objects or environments" (2012, p. 409). With a view to providing clarity in the following discussions, I mainly use the descriptor properties in place of affordances; my approach in this area is more deeply characterised in chapter three. Murray's research has been described as exploring the "connection between the properties and pleasures of digital media and the future of storytelling" (Salen and Zimmerman 2004, p. 416). In the context of this study, her theories may be valuable, as this project centres on the design of narrative-based digital books.

Computer science research around ideas of functional properties has been criticised for prioritising the ways in which systems operate, over the aesthetic, material and social qualities of artefacts (Dourish 2001; Jung and Stolterman 2012). With the aim of addressing aesthetic, material and social concerns relating to children's book applications, I present Murray's theories alongside other interaction design approaches (Jung and Stolterman 2012; Löwgren 2014; Löwgren and Stolterman 2004). I examine games research that analyses the relationship between interactive content and narratives (Juul 2001; Murray 1997). I draw on cognitive

Description of Project

science evaluation studies; this research reveals ways in which four- and five-year-old children respond to and understand book application content (Smeets and Bus 2013, 2014). I also analyse connections between digital and physical domains (Munster 2011, 2014). Finally, I draw on children's literary theory in order to further understand how children and adults can socially interact over picture books (Nikolajeva and Scott 2006), and I use this theory to draw connections between materials, making practices and physical activities and experiences.

Heekyoung Jung and Erik Stolterman note that interaction design can involve consideration of the functionality as well as the aesthetic qualities of a digital design (2012). I use the term 'functional' to describe the technical details relating to how a system operates. The term 'aesthetic', in this context, is used to describe the perceivable sensory aspects of a design, this idea is also connected to making practices and processes. This project involves analysis of computer science and arts-based methods of practice, and the social and educational implications associated with this area of digital design.

1.3 RATIONALE

There has been a sharp increase in the numbers of Western children who have access to and use mobile applications (Hourcade et al. 2015; McLean and Kulo 2013, p. 48). In 2011, 38% of children in the United States aged between zero and eight had used a mobile device; in 2013 this figure rose to 72% (Common Sense Media and Rideout 2013, p. 9). It is expected that these figures will continue to rise (McLean and Kulo 2013). Mobile applications are becoming an increasingly important factor in young children's lives.

Since book applications first emerged in 2010, there has been a rapid increase in their production and consumption (Yokota and Teale 2014). It appears, however, that technological developments have "outpaced" fundamental understandings of children's digital books (p. 577). As a result, theorists in the fields of literature and education are only beginning to grasp the technical and functional aspects of contemporary digital literature (p. 577). Conversely, the "aesthetic aspect of digital artifacts has not been dealt with in a significant extent" within the "technological tradition" of digital design; furthermore, social implications are "somewhat underdeveloped in interaction design" (Löwgren and Stolterman 2004, p. 53; Löwgren 2014). Through this project, I aim to provide designers and researchers, from science and humanities traditions, with practical and conceptual knowledge relating to the functional and aesthetic values of book applications.

Description of Project

This research highlights the ways in which children's digital books can serve and extend the valuable role that picture books have played within Western societies. Children's literature and education theorists Junko Yokota and William Teale state that, "picture books are a sophisticated art form that also serve significant roles in the literacy and literary development of children" (2014, p. 578). By engaging with picture books, a child can learn to "read" both words and images (Nodelman 1988). According to Yokota and Teale, there is "rich theoretical and research literature" relating to print picture books (2014, p. 578). These theorists note that although book applications have become a "major force" in children's contemporary literature, there is a scarcity of research relating to these items (p. 577). There is a lack of "dominant models" and "standards" within children's digital publishing (Hedlund 2012, p. 23).

Yokota and Teale detail ways in which educators and librarians can select culturally valuable and educationally useful book applications for children (2014). Cognitive scientists Daisy Smeets and Adriana Bus provide insights into how young pre- and semi-literate children respond to and learn from highly interactive, animated digital books (2013, 2014). Among this research there is a gap, a lack of literature that focuses on the design values of children's book applications. This project addresses this gap.

1.4 METHODOLOGY AND RESEARCH QUESTIONS

Within this study, I deploy an overarching methodology known as practice-based research. Linda Candy is a specialist in this applied methodological approach. She states that practice-based research is an "original investigation undertaken in order to gain new knowledge partly by means of practice and the outcomes of that practice" (2006, p. 1). My practice involves making a children's book application and analysing key design properties associated with these artefacts.

Within my methodological approach, I analyse the functional aspects of digital design (Murray 2012), particularly as they relate to children's book applications. These ideas are further informed by aesthetic-driven interaction design methods (Jung and Stolterman 2012; Löwgren and Stolterman 2004), traditional design approaches (Nikolajeva and Scott 2006), and ideas that connect digital and artistic practices with social and physical relations (Munster 2011, 2014; Nikolajeva and Scott 2006). In doing this, I analyse the link between book applications and printed picture books. Specifically, I address the relationship between book applications and the social and educational outcomes that printed picture books can give rise to.

Description of Project

Within the structure of this exegesis, I provide a review of literature; I acknowledge existing research from the fields of children's literature, interaction design, game design and cognitive science (Juul 2003; Löwgren 2014; Nikolajeva and Scott 2006; Smeets and Bus 2014), and I present a survey of existing children's book applications. This is followed by a detailed discussion of my theoretical framework; I examine Murray's theories of digital affordances (1997, 2003, 2012). In later chapters, I use Murray's theories to structure an analysis of a case study; the children's book application *The Fantastic Flying Books of Mr. Morris Lessmore* (Moonbot Studios 2011). Finally, I apply the knowledge gained through my theoretical and case study analyses to an examination of my own creative work *How Far is Up?* In conclusion, I present the new knowledge that has arisen as a result of making this artefact, and I illuminate some central areas of focus associated with remediating the picture book.⁴

1.4.1 Research Question One: The Theoretical Framework

How may Janet Murray's theories relating to the affordances of the digital medium operate as a framework for an analysis of the functional and aesthetic values of book applications?

In chapter three of this exegesis, I analyse Murray's theory of digital affordances (1997, 2003, 2012). Within her research, Murray supplies common principles, a design vocabulary, and a conceptual framework that is applicable to the design and analysis of all digital systems and artefacts (2012). I assess Murray's approach, with the view to establishing its applicability to an investigation of the functional and aesthetic aspects of children's book applications.

1.4.2 Research Question Two: A Case Study Analysis

How may we apply Murray's theories and theory relating to children's literature to an analysis of the book application The Fantastic Flying Books of Mr. Morris Lessmore?

⁴ The term remediation was developed by theorists Jay Bolter and Richard Grusin (2000). Murray states that remediation is the "phenomenon of reproducing the conventions or content or both of one medium in another" (2012, p. 435).

Description of Project

In chapter four of this exegesis, I use Murray's four affordances of the digital medium as a structural framework, and I apply a transdisciplinary set of theories to an in-depth examination of the book application, *The Fantastic Flying Books of Mr. Morris Lessmore* (Moonbot Studios 2011).⁵ Interaction designer Jonas Löwgren states that the "practice of interaction design is knowledge intensive and multidisciplinary at heart" (2014). Perhaps it is not surprising that I draw on a range of theoretical approaches in addressing this research question.

The Fantastic Flying Books of Mr. Morris Lessmore has been critically acclaimed; it is considered to be an example of best practice (Donahoo 2011; Machell 2011). As such, this case study may assist in demonstrating some of the central techniques used by designers of children's book applications.

1.4.3 Research Question Three: The Creative Project

How have the findings that emerged from the case study analysis informed the design of my own creative work How Far is Up? And has the process of making a book application revealed further insights into remediating the picture book?

In chapter five of this exegesis, I apply the insights gathered from my theoretical and case study analyses to an examination of my creative project *How Far is Up?* Within this transdisciplinary analysis, I maintain Murray's theories as a structural framework. In order to answer this research question, I assess the methods and materials that I used when making *How Far is Up?* and I examine the social and educational implications of my design and design approach.

1.4.4 The Scope of this Study

How Far is Up? is an application containing educational content and ideas relating to distance and space. Within this exegesis, I do not analyse the astronomical, educationally centred elements of my artefact's content. I do, however, focus on higher-level issues relating to how the design of book application assets can lead to educational outcomes.

⁵ Educational theorist Louis Richard Meeth states that transdisciplinary studies "start with the issue or problem" and bring to bear the knowledge of multiple disciplines, each of which contributes to the "solution or resolution" (1978, p. 10).

Description of Project

In this study I draw on literary theory, yet I do not address ideas relating to ‘book nostalgia’ or the ‘death of the book’, and I do not analyse children’s book applications in relation to semiotic concepts. I also do not analyse ideas relating to linguistics and the ways that book applications can provide users with multilingual features such as language translations. I draw on literary theory in order to analyse technical methods and aesthetic approaches associated with the design of children’s digital literature.

I do not engage in socio-political discussion regarding what digital art theorist, Anna Munster, calls digital “haves” and digital “have nots” (2011, p. 152); although I acknowledge that children’s book applications are only available to those who have access to electricity, the Internet and specific computer hardware. I also do not seek to unravel ethical issues relating to children’s application content, particularly as it relates to children’s access to specific Internet platforms. These areas of study are outside the scope of this research.

Within this project, I do not primarily seek to gain understandings of user responses to digital books; although I have conducted a participant evaluation study of the *How Far is Up?* application (refer to details in appendix A).⁶ I also do not aim to analyse the sales streams, the range of hardware and software, or the computer coding languages and coding processes that can be used to design children’s book applications. These areas inform part of my discussion, but are not central to my research inquiry. In short, I have focused this project on analysing a range of functional properties and aesthetic qualities within narrative-based children’s book applications.

The insights that emerge from this research may be applicable to the design and analysis of children’s digital works. The results of this study may also be relevant to researchers and practitioners in the fields of children’s literature, digital humanities and education, and to those in the disciplines of interaction design, application design, digital design and picture book design.

⁶ In the appendices, I have provided a summary of a participant evaluation study of *How Far is Up?* (refer to appendix A). These findings further support my research inquiry. They are provided as an appendix in order to allow this exegesis to focus on the design qualities of the artefact, as opposed to centring on user responses.

Many of the theories and practices involved in this research have also been evaluated through peer-review processes. There have been a number of research outcomes from this project. I have had six peer-reviewed papers published as a result of this research (refer to appendix B). *How Far is Up?* was also selected for exhibit at two international peer-reviewed interaction design academic events: the highly regarded Tier 1 exhibit at CHI Interactivity 2014, and Interactive Entertainment 2013 (refer to appendix C). The *How Far is Up?* application has also won an AIMIA finalist award (Australian digital industry award), and has been shortlisted for a Consensus Innovation Award (2015) and a Victorian Premier’s Design Award (2014) (refer to appendix D).

2

Review of Literature

In the introduction, I noted that book applications have emerged as a new picture book format, and I demonstrated a lack of existing models and standards within the discipline of children's book application design. My aim, in conducting this research, is to provide theoretical and practical knowledge relating to the functional and aesthetic values of book applications. This study may help further establish, for designers and theorists, how digital picture books can be of social and educational value to young children. This review of literature provides some context for this project.

I begin this chapter with an overview of research relating to children's literature. I focus on studies that note the relationship between the words and images in picture books, and ideas relating to the term 'narrative', and I assess developments in the design of children's digital stories (Madej 2003; Nikolajeva and Scott 2006). I then turn attention towards the field of human-computer interaction. In this discussion, I analyse the notion of design from an interaction design perspective (Jung and Stolterman 2012; Löwgren 2014). I discuss game design research that focuses on the relationship between interactive content and narratives, and concepts relating to virtual narrative environments (Jenkins 2004; Juul 2003; Murray 1997). I also identify cognitive science studies that assess the ways in which young children interact with and learn from book applications (Smeets and Bus 2014).

Finally in this review of literature, I address historical developments relating to the physical form of the book. This involves analysis of technical innovations associated with print and digital book formats (Eisenstein 2011; Madej 2003; Murray 1997). I particularly note research that focuses on children's contemporary digital books (Smeets and Bus 2014; Yokota and Teale 2014). I conclude with a survey of a range of children's book applications, noting their design qualities. Through this discussion, I aim to outline the diversity of approaches that designers can adopt.

2.1 CHILDREN'S LITERATURE: PICTURE BOOK AND NARRATIVE THEORY

Children's literature theorists M.O. Grenby and Andrea Immel, editors of the *Cambridge Companion to Children's Literature* (2009), state that children's literature can be in the form of prose, verse, drama, fact or fiction; it can also contain "texts" that are "composed solely of pictures or digital images" (2009, p. xiii). Unlike literature designed for "mature readers", children's literature is "defined by its intended audience", which includes infants "being read to", teenagers "on the threshold of adulthood" and adults (Grenby and Immel 2009, p. xiii). Adults may be involved in reading children's literature because they are assisting children, or they may be readers in their own right (p. xiii). Children's literature can contain diverse literary styles and involve a wide readership.

2.1.1 Theory Relating to Picture Books

One form of children's literature that is designed primarily for *young* children is the picture book. There are a variety of approaches to the study of picture books (Yokota and Teale 2014, p. 578). One approach to this research strand involves analysing the ways in which "illustration and text work in synergistic ways" (Yokota and Teale 2014, p. 578). For example, children's literary theorist Perry Nodelman assesses the aesthetic design qualities of picture book images, and the relationship between the words and images (1998). Similarly, Nikolajeva and Scott analyse the "inseparable entity of word and image" (2006, p. 6). These scholars highlight the methods used by designers, such as myself, who communicate children's stories through words and imagery.⁷

Another approach to analysing picture books is to investigate the role of the reader. According to Nikolajeva and Scott, reader-response theory, particularly the work of Wolfgang Iser (1978), provides a valuable approach to analysing picture book dynamics (2006, pp. 2, 26). Nikolajeva and Scott describe reader-response theory as it relates to children's literature. They state that there can be "gaps" between the words and images in picture books (p. 2). These gaps leave "room for the readers/viewers to fill with their previous knowledge, experience, and expectations" (p. 2). As a picture book designer, I am conscious that when readers interpret my visual and verbal texts, they may formulate their own individualised meanings or messages from the work.

⁷ Maria Nikolajeva and Carole Scott adopt a post-structuralist approach to their research, extending on the theories of Jacques Lacan (2006). Nikolajeva and Scott equate Lacan's "imaginary stage" with picture book images; they claim that these images operate as "preverbal signs" (2006, p. 261). They also draw connections between the Lacanian "symbol" and picture book language (p. 261). They state that "picturebooks bridge the gap between the verbal and nonverbal, creating an artistic form equally appealing to sophisticated and to less readers" (p. 262). In drawing this conclusion, Nikolajeva and Scott not only explore the "imaginary" and "symbolic" realms of communication, but "reconcile" the two (p. 261).

A further method of picture book analysis involves what Nikolajeva and Scott call the “dual audience”; that is, picture books have a readership that consists of both children and adults (2006, p. 21). Nikolajeva and Scott state that adults commonly assist children in deciphering narrative meanings from picture books (pp. 21–24). I am aware that *How Far is Up?* may attract an intergenerational readership: together, adults and children may be involved in assembling meanings from my application’s content. The social aspects associated with picture books informs the design methods that I deploy.

2.1.2 Narrative Theory

In order to establish firm parameters for this research, it may be useful to identify a historical context for the term narrative. According to narrative theorist Martin McQuillan, one of the many definitions for the term narrative stems from structuralist and post-structuralist theory⁸ whereby a “narrative consists of two parts: story and discourse” (2000, p. 323). This binary notion can be tracked from Russian formalism, where theorists such as Vladimir Propp describe narratives through the relationship between “fabula and “sjuzhet”, through a French structuralist tradition, where theorists such as Tzvetan Todorov described narratives through the notions of “histoire” and “discours”, to an Anglo-American tradition where the terms “story” and “discourse” are used (p. 4). Narratives are often considered to operate with a binary structure.

From a structuralist standpoint, narratives consist of two components: the telling of a chronological sequence of events (i.e. *fabula*, *histoire*, story), and how these events are told, communicated or portrayed (i.e. *sjuzhet*, *discours*, discourse) (McQuillan 2000, pp. 4–5). Literary theorist Peter Barry states that “‘story’ is the actual sequence of events as they happen” (2002, p. 223). As such, a story “has to begin at the beginning...and then move chronologically, with nothing left out” (Barry 2002, p. 223, emphasis in original). Barry notes that the term “discourse” is often synonymous with the term “plot”. These terms describe “events as they are edited, ordered, packaged, and presented”; a plot “may well begin somewhere in the middle of a chain of events, and may then backtrack” (p. 223).

⁸ The structuralist movement began in the 1950s (Barry 2002, p. 41); this movement has its roots in the foundational work of the linguist Ferdinand de Saussure (p. 41). Anthropologist Claude Levi-Strauss and literary critic Roland Barthes are central theorists within structuralist thinking (p. 39). Structuralism, in essence, “is the belief that things cannot be understood in isolation – they have to be seen in the context of the larger structures they are part of” (p. 39). In the “structuralist approach to literature there is a constant movement away from the interpretation of the individual literary work and a parallel drive towards understanding the larger, abstract structures which contain them” (p. 40). Where structuralism is derived from linguistics, post-structuralism is derived from philosophy (Barry 2002, p. 63). Post-structuralism emerged in the late 1960s; two central figures in this movement are Barthes and Jacques Derrida (p. 65). The post-structuralists built on the fundamental tenants of structuralist thinking, yet they also challenge the idea that the human being is an “independent entity” (p. 65). Post-structuralist theorists suggest that the “individual is really a product of social and linguistic forces” (p. 65). This movement, in a literary context, centres on “deconstructing” texts, with the aim of uncovering the “unconscious” as opposed to the “conscious dimension of the text” (pp. 70–71).

The concept of discourse also includes consideration of issues concerning narrative style, viewpoint and the pace of the events as they unfold (p. 223).

Some theorists collapse the delineation between the notions of story and narrative, thereby rejecting structuralist binary approaches (Smith 1981, pp. 228–31). Others extend structuralist narrative theory; for example, Gérard Genette emphasises and details temporal influences on narrative constructs (1985). The temporal dichotomies that can be identified through narrative theory assist us in understanding the challenges that narratives can face within the digital realm (Juul 2001), particularly in relation to non-linear narratives (Murray 2012).⁹ There is not a unified approach to narrative analysis. The concepts introduced here, particularly in relation to how narratives can operate in the digital realm, are further discussed within later sections of this literature review and in later chapters of the exegesis.

2.1.3 Children's Digital Narratives

Children's narratives can be produced in a variety of ways and they can involve a range of design practices and practical approaches. According to children's digital narrative theorist Krystina Madej, digital designers can use the full range of storytelling media and methods; digital stories incorporate oral traditions, print traditions, and television traditions (2003, p. 2). As such, digital stories can be comprised of "image, sound, and animation" as well as written text, and they can be formed through collaboration between "authors, multimedia artists, and software developers" (pp. 2, 8).¹⁰ Madej's research assists in establishing the range of computer science and arts-based design practices that can be included in the process of making a digital story.¹¹

⁹ Murray states that most print book narratives are linear, in that they follow a single sequence of events (2012, p. 430); she describes non-linear narratives as ones that contain "more than one valid, coherent path through a set of segments" (p. 430).

¹⁰ Alison Druin specialises in interaction design for children; she notes the ways that children can be a part of the digital design process through participatory design practices (2008). Druin states that design teams can incorporate children in the role of users, testers, informants or design partners (2008).

¹¹ Education and communication theorists Gunther Kress and Theo van Leeuwen may further inform these discussions (2001). In their title *Multimodal Discourse: The Modes and Media of Contemporary Communication*, they articulate a set of strategies by which we can understand, among other things, how we can communicate through multiple media components in digital and interactive media (p. 122). They describe their communication strategies as being discourse, design, production and distribution. Although these ideas may inform this study, Kress and Leeuwen base their ideas in semiotic theory. Within this thesis, I do not adopt a semiotic approach to understanding digital media. I apply a transdisciplinary approach that primarily extends from a designerly concept of interaction design, an approach that seeks to reconcile functional and aesthetic design properties and processes.

2.1.4 Summary: Children's Literature, Picture Book and Narrative Theory

In this discussion, I situate this project among research relating to children's literary studies. I particularly note the picture book theorists Nodelman, Nikolajeva and Scott. These scholars focus on the relationship between words and images, and on how audiences can form meanings from studying these aspects of printed picture books. I also note research relating to how designers can combine computer science and creative arts techniques and practices when shaping digital narratives (Madej 2003). This body of research assists me in analysing: the ways media can be combined in digital books; the social and educational implications associated with designing children's digital books; and the digital and non-digital practices that can be involved in this area of design.

I will now turn attention to assessing the scientific field of human-computer interaction as it relates to the design of children's digital storybooks. This is so that I can identify further studies that analyse the ways in which designers can shape stories for a digital environment.

2.2 HOW HUMANS INTERACT WITH COMPUTERS: A DESIGNERLY APPROACH TO CHILDREN'S STORYBOOK APPLICATIONS

Human-computer interaction (HCI) is the key research area that focuses on the ways that humans engage with computers. In his introduction to *The Encyclopaedia of Human-Computer Interaction*, John Carroll states that, this is an "area of research and practice" that emerged from within computer science in the early 1980s (2014). Developments in personal computing systems generated wider interest in this area. Consequently, human-computer interaction is now an arena of research and practice that is taught across science departments, as well as in departments that address art, design and communication (2014). Human-computer interaction is a vast interdisciplinary field.

The "original and abiding technical focus of HCI was and is the concept of usability" (Carroll 2014). When studying how humans interact with computers, computer science researchers commonly adopt "user-centred" approaches, where qualities such as "functionality, usability and performance" are prioritised (Jung and Stolterman 2012, p. 647). User-centred methodologies focus on

user needs and on the ways that digital systems technically operate. This often involves analysis of the “functionality of interactive systems at the expense of their aesthetic potentials” (2012, p. 646).

2.2.1 Designerly Approaches to Interaction Design

Interaction design is a discipline within the field of human-computer interaction (Löwgren 2014). This discipline has spawned interest in “a more designerly approach” to creating digital objects (2014). Interaction designer Jonas Löwgren describes a designerly approach as one that goes “beyond pure utility and efficiency to consider also aesthetic qualities of use” (2014). From a designerly perspective, the term “interaction design” can be traced to the theories of Bill Moggridge and Bill Verplank (2014). Moggridge states that interaction designers are “dedicated to creating imaginative and attractive solutions in a virtual world” where “behaviors, animations, and sounds” give “aesthetic pleasure” (2007, p. 14).

There are multiple fields and disciplines that address the idea of aesthetics including psychology, art, literature and film, as well as disciplines that are concerned with visual culture (Tractinsky 2014). According to interaction design theorist Noam Tractinsky, there is “a long tradition of relationship between aesthetics and technology” (2014). Tractinsky states that the concept of aesthetics, as it relates to technology, commonly revolves around positive influences on “emotional and cognitive processes” (2014). As a result of adopting an aesthetic-driven approach to design, “people’s experience with the technology” can improve, as can “their appraisal of it and their attitudes towards it” (Tractinsky 2014). In the context of this study, it is important to note Donald Norman’s work, particularly *Emotional Design: Why we Love (or Hate) Everyday Things* (2004). In these writings, he updates his previous findings (1998) by noting the role that aesthetics play in the interaction design process. Users’ attitudes and responses to a design are influenced by the design’s aesthetic formation.

According to Löwgren and interaction designer Stolterman, the term “aesthetics” relates to the “shape, form and color” of a digital design (2004, p. 53). Jung and Stolterman remind us that form describes “materials and shape as well as making approach” (2012, p. 646, emphasis in original). Interaction design materials can include “software, electronics, [and] communication networks” (Löwgren 2014), as well as non-digital creative arts media (Jung and Stolterman 2012, p. 650). According to Moggridge’s foundational concept of (designerly) interaction design, aesthetic considerations can also involve sound or audio experiences (2007, p. 14). It appears that aesthetic-driven interaction design methods can involve consideration of the material qualities, as well as the making practices that are involved in forming the sensory aspects of a design.

Review of Literature

It is important to note that Jung and Stolterman differentiate between the terms “materials” and “materiality”. These terms may be connected, yet we should, however, be clear about their distinct meanings. Materials are the physical items that are used to construct an artefact, whereas materiality can be defined as “the relationship between people (user) and the material artifact” (Jung and Stolterman 2012, p. 648). Art theorist Anna Munster acknowledges that there is not a “uniform” understanding of the concept of materiality; it is a complex notion that has “had a long history in various branches of sociology, aesthetics, and political science” (2014, p. 328). Munster states that materiality should not be “mistaken for a simple quality or property of digital technologies” (p. 328). Her understanding of this idea involves an appreciation of the sensory aesthetic qualities of an artefact, questions surrounding embodiment, and socio-political and historical “materialist” influences on digital media¹² (2011, 2014).

Interaction designer, Paul Dourish, establishes some foundational ideals in this area (2001). Dourish’s theories focus on notions of embodiment, he relates this idea to two strands of thought: how we can interact with physical objects that have become augmented with “computational abilities”; and how computing can involve “social practices” (2001). This notion of embodied interaction is based on the understanding that users create and communicate meaning through their interactions with a digital system, and they create meaning by communicating with each other *through* the system.¹³ In the context of this project, my approach to materiality, and the related idea of embodiment, has been informed by aesthetic-driven, interaction design methods of research and practice. This involves drawing a correlation between book application design and picture book design, particularly in relation to the aesthetic, social and educational qualities of that these artefacts can give rise to.

A broad range of meanings can be ascribed to the terms ‘design’ and ‘designer’. Interaction design theorists John Zimmerman, Jodi Forlizzi and Shelley Evenson state that “it is quite common for people to use the term design to mean HCI practice and to use the term designer to mean an HCI practitioner” (Zimmerman, Forlizzi and Evenson 2007, p. 2). They note that “a designer might be an interaction designer, a usability engineer, a software architect, a software developer” or someone who has extensive training or practical experience in disciplines such as architecture, product design, or graphic design (p. 2). Jung and Stolterman reinforce this idea when they state that interaction designers can incorporate “approaches from traditional disciplines (fine arts, craft, industrial, graphic design) and those from recent technical disciplines” (2012, p. 650). The term design, in this study, is used to describe the practice of forming both the technical computational aspects and the traditional creative arts-based properties of digital artefacts. I use the term designer to describe the practitioner, such as myself, who enacts this range of practices.

¹² Within these discussions, Munster raises the inequities surrounding access to the digital realm; this includes ideas around digital “haves” and digital “have nots” (2011, p. 152).

¹³ Dourish’s ideas stem from the foundational writings of Martin Heidegger (1927) and Ludwig Wittgenstein (1953).

Children's interaction design specialist Juan Pablo Hourcade notes the variety of approaches that can be adopted by designers when making children's digital products (2008). This includes ideas relating to children engaging in the design process as "design partners" (2008, p. 312). The roles that children can play, in the development phase of interactive products and technologies, has been well documented (Druin 2002, p. 3; 1999; Hourcade 2008; Markopoulos et al. 2008). Both adults and children can be involved in the design of interactive systems and items.

2.2.2 Interactive Content and Narratives: Informing Children's Digital Literature

Ideas relating to interactivity are applied across many fields. By the "early 1960s the concept of interaction had developed from an idea of reciprocity in biological, chemical and physiological processes into elaborate theories of social interaction (sociology), into a whole new science trying to establish the idea of feedback processes as a basic theorem of life and technology" (Kwastek 2008, p. 17). Within this study, I use the term interaction to describe social relations; specifically, relationships between adults and children who are engaged in shared reading of picture books (Nikolajeva and Scott 2006; Smeets and Bus 2013, 2014). I also use the term interaction to describe the ways that humans relate with media.

Interactivity is a term that has been widely used in digital games studies. Game theorists Katie Salen and Eric Zimmerman state that interactivity is the "process of action and outcome" (2004, p. 58). Interaction designer Bert Bongers describes this "two way process" through the ideas of "*control and feedback*" (2000, p. 479, emphasis in original). Designers can shape system processes and system responses so that they are logical and easy for users to comprehend. As a consequence, users may feel in control of an interactive artefact (Bongers 2000).

Game designer and theorist Chris Crawford notes that designers can form artefacts so that they contain different levels of interactivity (2003, p. 6). Interactivity can involve a degree of exchange. For example, an ebook may involve people in low levels of interactivity; readers may only be required to swipe a screen in order to turn a page. Yet a book application may contain high levels of interactivity, where users are required to complete tasks, or on-screen activities, in order to access the next section of a story.

Review of Literature

Scholars have formed a variety of viewpoints regarding what beings or items can be involved in interactive exchanges. According to Crawford, a printed book can never be interactive (2003, p. 8). Madej, however, provides us with a different perspective. She states that interactivity “is one of the key features of the digital environment...it is also used as a key feature in many young children’s books” (2003, p. 11). Most notably, Madej acknowledges that print picture book designers can create interactive features in order to “engage and entertain” readers (2003). For example, “pop-up, open-the-flap, and peep-through-the-hole books give children the opportunity to play and learn as they make things happen” (p. 11). In a literary context, digital interactive features can lead to readers becoming active participants; they become “users” of interactive digital media (Sargeant 2015).

The relationship between digital interactive features and narratives has been widely discussed in games research. According to designer and games theorist Gonzalo Frasca, there have been numerous theoretical approaches that have been applied to the study of games. Frasca states that, during the first decade of the twenty-first century, the broad range of approaches to games studies gave rise to a debate between two perceived factions; ludologists¹⁴ and narratologists (2001).¹⁵ During this debate, games theorist Jesper Juul maintained what became known as the ludologist’s perspective: Juul advocated for games to be informed by theory relating to play and games (Juul 2001, 2003). In contrast, during this time Murray adopted what became known as the narratologist stance (Jenkins 2004, p. 119): she applied narrative theory in her analysis of games.¹⁶ This literature forms a foundational backdrop. It informs my later discussions on the presence of interactive features and play activities in children’s storybook applications.

2.2.3 Narratives and Virtual Environments: Informing Children’s Digital Literature

This research project centres on a narrative-based digital artefact, one that features a story world constructed from written text, imagery and audio. In the following discussion, I briefly cover some broad factors involved in the design of virtual narrative environments. In 1983 novelist William Gibson coined the term “cyberspace” to describe a “virtual terrain” (Murray 1997, p. 22). When shaping a digital environment, designers often draw connections between physical and virtual realms (Murray 2012, p. 439). Media

¹⁴ The word “ludic” means “*of or relating to play*” (Salen and Zimmerman 2004, p. 303, emphasis in original). As such, ludic activities involve both game play and non-game-based play (p. 303). Game play “is the formalized interaction that occurs when players follow the rules of a game and experience its systems through play” (p. 303). An example of non-game-based play is “a kitten batting a ball of yarn” (p. 303). Play is less structured than games. Ludology, in its most elemental form, can be defined as the study of games and play (Frasca 2001). From this brief note, we can begin to see that this notion involves a relationship between two detailed concepts; games and play.

¹⁵ According to narrative theorist Martin McQuillan, narratologists examine “the nature, form and function of narrative across genre and media” (2000, p. 324).

¹⁶ During this time, interaction designer Brenda Laurel was applying classical dramatic theory to the study of digital games and virtual reality (2013).

theorist Henry Jenkins suggests that designers of digital narratives “don’t simply tell stories; they design worlds and sculpt spaces” (2004, p. 121).

Theorists often describe aspects of digital environments by using architectural terms such as “room” and “site”; and indeed a virtual terrain can be viewed as being, in itself, an “architecture” (Jenkins 2004; McCullough 2004; Mitchell 1995; Wiltse and Stolterman 2010). The discipline of architecture operates as a valuable resource for digital designers, as it “has always been concerned with the design of spatial layout” (Bongers and van de Veer 2007, p. 107).

Electronic environments can involve “virtual and augmented reality, interactive artworks, electronic games, 3D MUDs [multi-user domains]...and architectural simulations” (Innocent 2003, p. 73). Digital media theorist Lisa Dethridge suggests that, as a result of exposure to a vast array of spatialised technologies and media, “we are seeing more innovative and avant-garde treatment of plot, characters and chronology” (2003, p. 113). Many digital game environments, for example, involve the navigation of avatars¹⁷ around highly detailed, explorable virtual terrains. The collection of literature noted here foreshadows wider discussions on virtual space and character representation within later chapters.

2.2.4 Cognitive Science: Informing the Design of Children’s Digital Literature

Another discipline in the broad field of human-computer interaction research is cognitive science. In describing this discipline, Carroll explains that the “broad project of cognitive science” involves the study of how humans use and understand information, particularly digital information (2014). Within this area of research, scholars such as Richard E. Mayer, Roxana Moreno, Daisy Smeets and Adriana Bus study children’s responses to digital materials. This research involves evaluation via participant studies.

Mayer and Moreno study the ways in which school and university students comprehend data that is presented in “text, animation and audio” form (2002). Their findings show that people form stronger understandings of information when it is presented using both visuals and audio (p. 95). Their research establishes some clear ideas on the ways in which young people understand and learn from

¹⁷ The term avatar is derived “from the Hindu concept of a god embodied in different beings” (Murray 2012, p. 411); a digital avatar is “a character within a virtual world who represents” the player (p. 411).

Review of Literature

audio-visual material. Some of their findings may be relevant to this study, even though Mayer and Moreno's data is derived from testing literate, as opposed to pre-literate, children.

Smeets and Bus track the eye movements of pre- and semi-literate four- and five-year-old children who are reading "storybook" applications (2013, 2014). These theorists note the levels of attention given to specific digital book features, and they evaluate the ways in which digital storybooks contribute to "children's language and literacy development" (2013, p. 178). Smeets and Bus state that digital storybooks may contain features such as "live-action video, digital graphics, animations, music, sound effects, and interactivity of text" (2013, p. 176). Most commonly these works contain an "animated presentation of the story" (Smeets and Bus 2014, p. 1). *How Far is Up?* is primarily designed for children aged four and five; Smeets and Bus' studies establish concrete perspectives on how this demographic interact with, read, and learn from media-rich book applications.

2.2.5 Summary: A Designerly Approach to Children's Storybook Applications

In this discussion of literature from the field of human-computer interaction, I note disciplines such as interaction design, game design and cognitive science. In doing this, I introduce Löwgren and Stolterman, who adopt a designerly approach to interaction design. I discuss theory relating to interactive content, narratives and virtual space (Juul 2001; Murray 1997). I also note cognitive science studies that address the ways in which children learn from and respond to audio-visual information and book applications (Mayer and Moreno 2002; Smeets and Bus 2014). This literature informs the analysis of a case study and analysis of my creative project in upcoming chapters. I will now turn attention to research that describes and discusses the design of the book from a historical perspective.

2.3 HISTORICAL DEVELOPMENTS RELATING TO THE BOOK: THE ORIGINS OF BOOK APPLICATIONS

There are numerous theories relating to books and book formats. In the following discussion, I trace a historical perspective of book design with an emphasis on children's picture books, and I provide a survey of contemporary children's book applications.

2.3.1 Printed Books: Origins and Developments in Children's Books

Recorded history, of European traditions of oral storytelling, dates from Ancient Greek civilisations (Murray 1997, p. 188). Epic, performance-based poetry, such as the *Iliad* and *Odyssey* produced around the eighth century B.C., are examples of the "collective effort of an oral storytelling culture" (p. 188). Ancient Greek and Roman writers also produced written and illustrated bound texts (Eisenstein 2011, pp. 23–24). These texts can be seen as codex; that is, manuscripts "divided into pages and bound together" (2012, p. 413).¹⁸ These ancient texts are a touchstone within Western societies; they mark a crucial development in book design.

In the middle of the fifteenth century, technical innovations led to written forms of communication being produced in printed form within Western societies (Eisenstein 2011). Murray states that following the development of Gutenberg's printing press, it took "fifty years of experimentation" to establish the conventions of printed books (1997, p. 28). It was not until early in the sixteenth century that the printed book became a "coherent means of communication" (p. 28). Since this time, there have been numerous print-related technological developments that helped shape the form of the book. Notable among these are the wooden handpress, movable type, offset printing, and colour and digital printing. For a period of approximately five hundred years, printing was the foremost means through which books were published (Eisenstein 2011).¹⁹ Marshall McLuhan offers a prelude to Eisenstein's discussions on the cultural implications of the printing press; McLuhan emphasises the ways in which the invention of movable type has mediated our "forms of experience" and our "mental outlook and expression" (2011, p. 2, emphasis in original).²⁰

¹⁸ Murray differentiates between codex and manuscripts that are presented in the form of "scrolls" (p. 413). A codex book may be handwritten or printed; it may also be "illuminated" or illustrated.

¹⁹ Historian Elizabeth Eisenstein details "attitudes towards printing and printers" across five centuries of Western history (2011, p. ix). Her considered historical analysis describes political and religious responses to printing, and the associated social effects. Eisenstein's research, as this book's title suggest, covers attitudes relating to the "first impressions" of printing through to what she labels as being a "sense of an ending" (2011).

²⁰ McLuhan tracks human communications from spoken word to written word (via the phonetic alphabet), to movable type (the Gutenberg revolution), and he begins to examine patterns of automated electronic communications and a matrix of human services (2011; 1968, p. 307). In doing so, he supplies us with a basis from which we can further understand developments in print technology and more current notions of networked society (e.g. Castells 2010) and globalisation theory (e.g. Steger 2011).

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Nodelman cites *Orbis Sensualium Pictus*, first published in 1658 (Comenius 1976), as being the first published picture book (1998, p. 2). This work is “an ‘illustrated catalogue’ that uses ‘pictures to define the meanings’ of accompanying words (Nodelman 1988, p. 2). Grenby argues that the publication of John Newbery’s *A Little Pretty Pocket-Book* in 1744 marks the single most important point of origin for children’s literature (Grenby and Immel 2009, p. 4). Newbury’s “pocket-book” (2009) includes descriptions of children’s games.

According to Madej, the inclusion of play and interactive designs in children’s books can be traced to a four-hundred-year-old educational concept (2003, p. 5). In the seventeenth century, philosopher John Locke spearheaded an educational movement that acknowledged childhood as a distinct developmental phase. In his book *Some Thoughts Concerning Education*, Locke recommends that a child’s sense of play should be encouraged (1996). He advocates for children’s education that involves play and games. Locke suggests that children’s texts should support a sense of play, as opposed to simply present rules regarding moral etiquette (1996). He states that children “must not be hindered from being children or from playing or doing as children” (1996, p. 45). Locke’s ideas helped to establish the notion that children are not just miniature adults; they possess their own distinctive needs.

As a consequence of this notion of childhood, and the idea that a child’s sense of play can be harnessed and used as a positive educational tool, authors and illustrators began to design play-based literature. For example, in the late nineteenth century, Lothar Meggendorfer designed intricate pop-up books that contained moveable elements (Meggendorfer, 1979). Interactive and play-based features began to be incorporated into book design as a means to engage children in literary works.

During the twentieth century, children’s books incorporated wider media features. For example, Jan Pieńkowski’s *Phone Book* (1991) features text, still and moving imagery and inbuilt audio. When readers open and close *Phone Book*, the pop-up paper-sculptured images move, and when they press a button, readers hear the sound of a telephone ringing. Readers are “invited to move the pop-up visuals and trigger inbuilt audio. The book responds and alters according to specific user touch and movement” (Sargeant 2013, p. 31). This work contains a level of moving imagery and inbuilt sound.

During the latter part of the twentieth century, innovations in computer technology led to digital devices becoming increasingly smaller, faster, cheaper and interconnected (Murray 1997, p. 27). In line with these developments, digital book production and consumption progressively rose (McLean and Kulo 2013; Yokota and Teale 2014, p. 577). Just as the printing press had a distinct impact on codex

books, the computational environment now stands as the second technological catalyst to significantly affect literature and literary production (Sargeant 2015).

In defining the contemporary book, media theorist Bill Cope states that a book “is no longer a physical thing. A book is what a book does. A book is not a product. It is an information architecture” (2001, pp. 6–7). Books can be handcrafted, printed or digital artefacts. They can also be presented in audio formats. In addition to this, children’s literary theorist Perry Nodelman reminds us that books can be constructed entirely from visuals, with no written text (1988, p. vii).

Some theorists state that these wide definitional parameters, and the digitisation of books, may serve to unravel the very nature and value of the book itself (Birkerts 2006). Regardless of decrees proclaiming the death of the book, it is likely that both print and digital book formats will continue to operate in coexistence for some time (Eisenstein 2011, p. 245; Yokota and Teale 2014, pp. 577–78). People require electricity, the Internet, and computational hardware in order to access and read digital books. Print technology is effective in producing a simpler, and to some a more convenient, format (Murray 1997, p. 27). The digital realm can, however, offer readers a wider scope of information than that available in printed works (Madej 2003, p. 2; Sargeant 2015).

2.3.2 Ebooks for Young Children

Digital books are often called ebooks; a term that is a contraction of “electronic book” (Garrish 2011, p. 1). Many early ebooks took on a similar form to “their printed counterparts with a cover, frontispiece, and pages to turn” (Madej 2003, p. 9). For example, *Red* (Sargeant 2012) adheres to this type of layout: it is an ebook that primarily contains written text and static imagery (refer to Figure 2).

Red is essentially a digital replica of a printed book. That is, it is organised in a similar manner to a printed book, with virtual verso and recto pages and a virtual gutter that divides the page. It retains visual design structures that derive from print book features. This book has clear ‘skeuomorphic’ elements.

The term skeuomorph originates from the field of archaeology. This term has been adapted to also describe the ways in which traditional design features are used as ornamentation in the digital realm (Gessler 1998, p. 229). Computer scientist Nicolas Gessler states that skeuomorphs “provide us with familiar cues to an unfamiliar domain” (1998, p. 229). An example of a skeuomorph is

evident in Figure 2: the virtual pages depicted in this image are ornamental, and their design is derived from functional structures found in printed books.

Figure 2
Red, Sargeant 2012.
This ebook mainly features
static imagery and text.



Madej states that some digital book designers take “greater advantage of the digital environment”; they provide readers with “interactive opportunities” (2003, p. 10). She says that in interactive digital books, “children can click on objects to bring short animation sequences to life” (p. 9). *Red*, for example, also includes interactive animations. When readers touch or select specific fish (visible in Figure 2), the fish move; this is accompanied by a brief sound effect. In designing this work, I have included a level of

interactive features, involving moving imagery and audio. Yet it must be said that this ebook incorporates a fraction of what is possible within the digital domain.

Ebooks that are designed for older readers may contain hyperlinks and hypermedia. That is, they can “connect readers with a wider scope of information than that which is available within printed books” (Sargeant 2015). Media theorist Ted Nelson describes “hypermedia” as a digital design method whereby “films, sound recordings, and video recordings” can be arranged “as non-linear systems” (1965, p. 96). Nelson limits the definition of his prefix “hyper-”, specifying that it “connotes extension” (p. 98). As such, hyperlinks may be viewed as being the connectors that affiliate different digital media data. These types of connections are formed in such a “complex way” that they “could not conveniently be presented or represented on paper” (Nelson, 1965, p. 96).²¹ Children’s book applications commonly provide users with hyperlinks.

Tablet computing systems that emerged around 2010 added new “visual and aural dimensions” within multifunction devices: devices designed for reading, browsing, gaming and audio (Garrish 2011, p. 6). Computer scientist Matt Garrish notes that developers responded to these advancements in computer hardware by creating software that allows designers to include more complex levels of audio, video and interactive features in their books (2011, p. 6). One such software upgrade is known as “EPUB 3” (Garrish 2011). A parallel movement in software development resulted in books being produced in application format (Wikert 2012).

Book applications are often designed for mobile touchscreen devices such as computer tablets and smartphones. A book application can include written text, animation, music, sound effects and high-level interactive features (Smeets and Bus 2013, p. 176). They may be viewed as being different to ebooks. Due to the high levels of interactivity and media-rich content in book applications, people “use” rather than read this new medium (Sargeant 2015). People read ebooks; people play, watch, read, listen and respond to book applications. As a result, book applications are made up of scenes containing content, rather than pages containing words and images.

²¹ Ted Nelson’s notion of “hypertext” is one that involves “interconnections” (1965, p. 96), that is, a two-way connection between linked data. This is an idea that is demonstrated in his ongoing project *Xanadu*.

2.3.3 A Survey of Book Applications

[For copyright reasons third party images have been removed from this section of the exegesis. The images were included in previous unpublished and examined versions of this work.]

In the following discussion, I provide an overview of a range of book applications. I begin with an assessment of *The Monster at the End of this Book* (Sesame Workshop 2011); I then spotlight a series of other applications with the aim of emphasising a variety of design approaches. The following book applications are categorised, within the App Store, as being works for audiences aged “4+”; they are designed for users aged four and above (for example, Sesame Workshop 2011).

The Monster at the End of this Book is an application that is based on the 1971 print picture book of the same title (Stone and Smolin 1971). The designers of this application have remediated the original book, producing a multi-sensory digital experience for the user. Yokota and Teale state that some designers of children’s book applications transform print picture books and “include features unique to the digital world” (2014, p. 579). For example, users can engage with *The Monster at the End of this Book* by: reading text; watching animation; listening to audio narration, music and sound effects; and altering the content by tapping or swiping the touchscreen.

The Monster at the End of this Book contains a story and a set of supplementary book-related activities. The story is the central aspect of this application; it comically addresses thematic material relating to children and a fear of monsters (Sesame Workshop 2011). The story features a protagonist, Grover, who is scared of monsters. Grover fears that, due to the book’s title, he will find a monster at the end of the book. For this reason, he attempts to stop readers from getting to the work’s conclusion.

Grover is not only the protagonist, but also the book’s narrator. This provides users with what Nikolajeva and Scott call a “metafictive” structure, whereby a “narrator frequently addresses the reader” (2006, pp. 222–23). Studies show that these kinds of metafictive “digital tutors” (Smeets 2012, p. 66) or “conversational agents” (Mori et al. 2011, p. 825) may assist young children in understanding an application’s content. For example, Grover operates as an animated guide: he assists users in operating the application and he verbally encourages users to interact with story content.

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Smeets and Bus' findings reveal that animated digital books "are more effective in attracting children's attention" than static ebooks (2014, p. 17). Moving imagery is alluring; it captures children's focus. The designers of *The Monster at the End of this Book* use animation as a means of drawing users' attention to written text. They progressively highlight the text; it is animated and illuminated in sequence with the words spoken in the audio narration. Further to this, at the beginning of the story, the designers show Grover underlining words with his finger as he 'reads' aloud. The character's actions are synchronised with the audio narration. The protagonist is replicating the actions that adults often make when engaging in shared reading of printed picture books. In this instance, the designers have used the alluring quality of animated imagery to form a relationship between the protagonist and the written text.

The designers of this application have also created a work that is interactive. Yokota and Teale state that interactive features are a central component of children's book applications (2014, p. 579). The interactive activities in this application are linked to the book's narrative; they focus users towards the act of confronting an imagined monster. As users progress through *The Monster at the End of this Book*, they must touch and swipe the screen in order to dismantle barriers that Grover has constructed. Through enacting these touchscreen gestures, users are provided with access to the following sections of the story. These interactive features relate to the narrative content; by interacting with, and progressing through the book, users show that they are willing to face the monster that is reportedly at the conclusion of the work.

There are numerous ways in which designers may invite users to interact with book application content. One of the first children's book applications to come onto the market was *Astrojammies* (Williams-Ng and Demibooks 2010). The designers of this application allow users to move the protagonist around a scene by tilting the mobile device. Many mobile devices are fitted with what are known as accelerometer and gyroscopic components. In this instance, these hardware components allow users to move on-screen objects in relation to the ways in which they are tilting or shaking their device. When undertaking these actions, users can interact with and change application content by enacting specific movements; they can become physically engaged with literature.

Designers can use mobile hardware features to fulfil different purposes. For example, the designers of *The Three Little Pigs and the Secret of a Popup Book* (Game College LLC 2010) use the device's gyroscopic, accelerometer and touchscreen capabilities to reproduce a digital version of a printed activity book. When users touch a specific on-screen object in *The Three Little Pigs and the Secret of a Popup Book*, an image containing a series of virtual springs, levers and pulleys is revealed. The designers invite users to

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engage with this imagery by tilting, tapping, and swiping the device. These activities may be intriguing and fun, yet they do not relate to the three little pigs story. They do not contribute to the central narrative.

In the book application *Even Monsters Get Sick* (Busy Bee Studios 2014), users can engage with interactive features by navigating a character through a maze. In contrast to the interactive features in *The Three Little Pigs and the Secret of a Pop-up Book*, this activity in *Even Monsters Get Sick* helps to support the story content. Users can assist the protagonist in finding his way home by engaging with the touchscreen; they can 'drag' the character through a maze in order to help him arrive home. This activity supports and propels the narrative.

Not all book applications contain narratives. For example, *Guess Who at the Zoo* (What's the Fuss 2011) is an activity book. This work is a digitised version of an 'open-the-flap' print picture book. Animals are partially concealed behind visual barriers; users swipe the screen to reveal the creatures in their entirety. *Animalia* (Base Factory and AppBooks 2013) is also an activity-based book application. This work offers users high levels of interactive content. In this application, users find hidden items within the intricate detail of Graeme Base's illustrations. The activities in this application could be categorised as games.

Many commentators commonly describe the activities that are present in book applications as being "games" (Smeets and Bus 2013, 2014; Yokota and Teale 2014). It may be worthwhile to pause and briefly analyse this term, in order to establish some clarity within this discussion. According to Juul, games are a "rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, [and] the player feels attached to the outcome" (2003). Within the *Animalia* application, for example, there are rules, the activities are timed, and users can accumulate a score; this work contains games. Users can reset games by shaking the hardware device.

It is also important to note that the idea of games can be seen to differ from the more general notion of 'play'. According to Salen and Zimmerman, play can be viewed as "free movement within a more rigid structure" (2004, p. 304). For example, the designers of *The Heart and the Bottle* (HarperCollins 2010) application invite users to draw pictures; these user-generated images are then displayed on subsequent pages of the book. This is a play-based activity in which children can freely express themselves within the more rigid structure of the linear story.

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It may also be important to acknowledge that play and game activities can be seen to differ from the idea of ‘puzzles’. Puzzles are viewed as a more structured sense of play, yet, they tend to be less structured than formal games (Sargeant 2013). Puzzles “hide a solution, and the player must experiment to divine that solution” (Crawford 2003, p. 161). Book applications can contain virtual jigsaw puzzles, whereby users can ‘drag’ puzzle pieces across the screen in order to form a unified picture, as seen in the book application *The Fantastic Flying Books of Mr. Morris Lessmore* (Moonbot Studios 2011).

Some book applications contain a more complex puzzle structure. For example, the narrative-based book application *Little Red Riding Hood* (Nosy Crow 2013) may be considered to contain a puzzle-like framework. This book has a non-linear structure. Users may select from a variety of paths when choosing which way Red Riding Hood will travel to her grandma’s house. The path that the user selects affects the story’s ending. The designers involve users in uncovering hidden solutions to this narrative puzzle.

In acknowledging the differences between play, puzzles and games, it becomes clear that these terms describe different activities. Many book applications contain play activities and puzzles; very few incorporate structured games (Sargeant 2013, p. 32). As noted by Juul, there are temporal complexities involved when designers combine games and narratives (2001). Plot devices can distract players from gaming action. For example, a player may be required to observe or respond to narrative information and this may disrupt their experience of game play (Juul 2001).²³ Games designer and theorist Ernest Adams also notes that narrative-based games can present players with a competing set of “motivational” forces (Adams in Jenkins 2004, p. 118). Adams’ concepts on user motivation will be revisited in later chapters.

Some book applications, like some picture books, contain narratives that do not involve written text. For example, *Nighty Night* (Fox and Sheep GmbH 2013) is a bedtime story in which users ‘turn off’ a series of lights so that farmyard animals can go to sleep. There are no written words in this work, yet the audio narration is offered in twelve different languages. Users can select the language in which they want the story to be told.

²³ Juul problematises the ways that narrative temporality can influence the game-play in “action” computer games. Juul describes the difficulty that players face in reconciling the sense of time that is reflected in a narrative’s discourse with real-time game-play action (2001). For Juul, the player’s sense of the here and now (what may now be called “presence”) can be disrupted by classical narratological structures (2001).

Children’s literary theorist Clare Bradford adopts an alternative perspective. Bradford suggests that players within computer games have the cognitive ability to “shift between the remote...the immediate past, and the present” (2012, p. 118). Players can also successfully “shift between narrative points of view” and character/avatar “perspectives” (p. 118).

Finally, book applications can also contain supplementary materials. For example, the supplementary materials in *Rules of Summer* (We are Wheelbarrow 2013) are accessed when users touch an arrow on the left-hand side of the homepage. The designers have shaped these materials so that users can directly connect with the social networking platform Facebook, and directly navigate to webpages and an online store. Through these supplementary materials, users can also join a mailing list and send an automated email to any contacts that are listed on the mobile device. *Rules of Summer* is designed for audiences aged four and above. The application's supplementary features, however, do not appear to be designed for young children; for example, Facebook requires its users to be over twelve years of age (Facebook 2015). In my later analysis of the central case study, I will revisit these kinds of design issues, although this is not a central aspect of my research inquiry.

2.3.4 Summary: Historical Developments Relating to Young Children's Books

In summary, this review of historic developments relating to the design of books identifies differences between printed books, ebooks and book applications. In my survey of book applications, I identify the ways in which these works can include an array of interactive features. I also note that children's attention is drawn to animated imagery (Smeets and Bus 2013, p. 179). Within this discussion, I demonstrate how book applications may include a fusion of written text, animation, audio and highly interactive features. It appears that designers can deploy interactive activities, and the alluring quality of animation, as a means of supporting or distracting users from narrative content. This selection of literature helps establish some key aspects of book application design; the concepts and practices outlined here inform the design approach that I have adopted when making *How Far is Up?*

2.4 CHAPTER TWO CONCLUSION: A REVIEW OF LITERATURE

In this chapter, I highlight children's literature research that identifies how designers shape written text and imagery in narrative-based picture books (Nikolajeva and Scott 2006). I acknowledge human-computer interaction research that relates to a designerly approach to interaction design (Jung and Stolterman 2012; Löwgren 2014). I also note ideas relating to digital interactive features, narratives and virtual environments (Jenkins 2004; Juul 2003; Murray 1997), and research that addresses the ways that cognitive science studies may inform this project (Smeets and Bus 2013, 2014).

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I will now focus on analysing Murray's affordances theories. In the following chapter, I investigate how these theories may be applied as a framework that allows for a deeper analysis of the functional and aesthetic values of children's book applications. In doing this, I also draw on the collection of research established in this literature review. In later chapters, I apply Murray's theoretical framework to a central case study analysis, and to an examination of my own creative work *How Far is Up?*

3

Theoretical Framework: Janet Murray's Four Affordances of the Digital Medium

Janet Murray's early research, as reflected in her 1997 book *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*, focuses on the ways in which narratives operate in digital environments, particularly in relation to game design (Salen and Zimmerman 2004, p. 416). Murray's later research, as evident in her 2012 book *Inventing the Medium: Principles of Interaction Design as a Cultural Practice*, focuses more centrally on how designers can use computer processing and programming to form digital systems and artefacts (p. 434). In this later work, she also examines ways in which designers can invite users to participate within media-rich digital spaces (Murray 2012, pp. 418, 432).

In her research, Murray identifies a set of "affordances" or properties that are common to all digital artefacts (1997, 2003, 2012). In this chapter, I draw focus to these digital attributes. I then use them, in later chapters, as an analytical tool in a case study analysis and in an assessment of my own project *How Far is Up?*

3.1 RESEARCH QUESTION ONE

How may Janet Murray's theories relating to the affordances of the digital medium operate as a framework for an analysis of the functional and aesthetic values of book applications?

In order to answer this question, I analyse Murray's theories on the "affordances of the digital medium" (1997, 2012). The concept of affordances can be traced to theories devised by psychologist James J. Gibson (Gibson 1979, 1982). Gibson established the term as a way of describing the "action possibilities" of a "material object" (Murray 2012, p. 410).²⁴ Norman further developed Gibson's concept of affordances, when he applied these ideas to the digital environment (1988, 1990, 2004). Norman is "specifically interested in manipulating or designing the [digital] environment so that utility can be perceived easily" (McGrenere and Ho 2000, p. 4). His understanding of affordances theories encompasses the "action possibilities" of a system or artefact, as well as how the action possibility is made visible to users (p. 3).

The central difference between Gibson and Norman's approaches to affordances is that "for Gibson an affordance is the action possibility itself", whereas according to Norman, an affordance relates to "both the action possibility and the way that the action possibility is conveyed or made visible" (McGrenere and Ho 2000, p. 3). Norman states that, there can be "both real and perceived affordances, and the two need not be the same" (2004). Murray's theories relating to affordances stem from Norman's studies (Murray 2012, p. 410).

The concept of affordances has been widely discussed (Carroll 1990; Gaver 1991; Gibson 1977, 1979, 1982; McGrenere and Ho 2000; Norman 1988, 1990, 2004; Suchman 1987; Winograd and Flores 1987). Interaction designer Bill Gaver reminds us that, "Gibson focuses almost exclusively on affordances which may be seen. But affordances may be perceived using other senses as well" (1991, p. 4). Gaver states that the idea of affordances "encourages us to consider devices, technologies and media in terms of the actions they make possible and obvious. It can guide us in designing artifacts which emphasize desired affordances and de-emphasize undesired ones....[It] allows us to focus not on technologies or users alone, but on the fundamental interactions between the two" (p. 5). Regardless of debates surrounding notions of actual or real affordances, and visible or perceived affordances, this

²⁴ In his book *The Ecological Approach to Visual Perception* (1979), Gibson describes three fundamental properties of an affordance (McGrenere and Ho 2000). Firstly he notes that there is no separation between human or animal actions and the environment in which these actions are carried out; secondly Gibson suggests that an affordance exists regardless of whether it is perceived to exist or not; finally, he notes that an affordance does not change in accordance with the changing needs and goals of those taking action (McGrenere and Ho 2000, pp. 1–2).

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term is deployed in an attempt to gain deeper understandings of how designers can shape digital works. Yet due to the strength of the debate surrounding the idea of digital affordances, it has become a somewhat contentious term.

It is not my intention for this thesis to focus on debates surrounding affordances theories, nor do I have the central aim of contributing to these debates. My aim is to better understand how to design the functional and aesthetic qualities of children's storybook applications. For this reason, when analysing Murray's theories within this chapter, I retain her use of the term affordance; within chapters four and five, however, I mainly use the term properties when describing the qualities and attributes of digital systems.

In her theories, Murray proposes that there are four properties that are common to all digital artefacts; she calls these the encyclopaedic, procedural, participatory and spatial affordances of the digital medium (1997, 2003, 2012). The encyclopaedic affordance, according to Murray, provides designers with access to computational "capacity", and this allows them to create digital artefacts that can be formed from a range of "media formats and genres" (Murray 2012, p. 418). The procedural affordance describes the "processing power of the computer", a power that allows designers "to specify conditional, executable instructions" (Murray 2012, p. 434). The participatory affordance allows users to "manipulate, contribute to, and have an effect on digital content" (p. 432). Finally, the spatial affordance, according to Murray, allows designers to digitally "represent space" that "can be navigated" by the user (pp. 438–39).

I begin this discussion by analysing Murray's theories on the encyclopaedic affordance. Her ideas in this area highlight the vast quantity of information that digital designers can present within the digital medium. As such, these theories may provide an effective overview of the methods, subject matter and structures that can constitute book application content. In the following sections of this chapter, I analyse Murray's concepts relating to the procedural, participatory and spatial affordances. My aim is to assess how Murray's ideas may operate as a framework for the analysis of the functional and aesthetic values of children's book applications.

3.2 MURRAY'S ENCYCLOPAEDIC AFFORDANCE OF THE DIGITAL MEDIUM

Murray states that computational capacity allows designers to “represent enormous quantities of information” and this “translates into an artist’s potential to offer a wealth of detail, to represent the world with both scope and particularity” (1997, p. 84). She calls this computational property the “encyclopaedic affordance of the digital medium” (1997, 2012).

In describing this affordance Murray identifies the range of media formats and genres that can be housed in digital artefacts. These include: “text, moving images, photographs, drawings, animations, musical recordings, audio recordings, live image and sound, three-dimensional models, databases, search engines, and video games” (2012, p. 418). Encyclopaedic digital capacity equips designers with the means to shape detailed artefacts formed from a range of different media.

When designers combine media formats and genres, this leads to the “phenomenon of media convergence” (Murray 2012, pp. 66, 415). Murray describes convergence as the intersection of media and the conventions used to shape those media (2012, p. 415).²⁵ She goes on to note that “designers must be able to distinguish between the many possible conventions that can be deployed in any application and decide which is the one best suited to the artefact they are making” (p. 10). Her theories on media convergence and media conventions highlight the need for digital designers to identify the range of protocols that they can use and the purposes that the protocols serve.

In summary, Murray’s ideas on the encyclopaedic affordance of computing may supply a useful framework for analysing the ways in which digital designers can provide users with levels of scope and particularity. She also highlights the combinations of media and media conventions that designers can use. In the context of this study, Murray’s ideas on this property of computing may be further informed by scholarship that focuses on the conventions used in picture book design (Nikolajeva and Scott 2006). Upcoming analysis will also account for the ways children understand and learn from the media content within book applications (Smeets and Bus 2013, 2014).

²⁵ Convergence is a concept that is commonly discussed from a socio-political perspective. According to Jenkins, convergence is “the flow of content across multiple media platforms, the cooperation between multiple industries, and the migratory behavior of the media audiences” (2006, p. 2). Jenkins’ concept of “convergence cultures” is overtly socio-political. Murray, on the other hand, supplies a different perspective. She states that in “digital media, convergence means the intersection of genres that were formally separated by incompatible means of inscription and transmission” (2012, p. 415). She does not adopt a socio-political stance when describing this idea.

3.3 MURRAY'S PROCEDURAL AFFORDANCE OF THE DIGITAL MEDIUM

According to Murray, the digital medium is “intrinsically procedural” because computers are machines (1997, pp. 71–72; 2012, pp. 321–22). She states that “procedures”, in a computer science context, are “sets of instructions that the machine will execute” (2012, p. 434).²⁶ Murray describes the ways that computer programmers specify a range of procedures that operate as governing forces; these procedures shape the behaviours of a digital system or artefact (2012, pp. 52–53). These ideas may assist in identifying the functional, computational aspects of book application design.

Murray states that when “procedurality is well designed the actions of the computer have visibility” and this can make the “processing of the computing machine clear” to the user (2012, pp. 434, 444). One central way that visibility has been achieved in computing is through the use of an interface. An interface is described as the “hardware and software through which humans and a computer...communicate” (Laurel 1990, p. xi). It is common to “equate the interface with the screen” (p. xi), yet there has been a shift away from this notion (Bolter and Grusin 2000, p. 23; Dourish 2001; Laurel 1990, p. xi;). Within this study, the interface is the iPad hardware, and the application software.

To ensure that computational procedures are clear to users, digital designers create visible “objects” (Murray 2012, p. 432). Objects can be in the form of written text, imagery or audio. Murray states that in a computational environment, objects are items that “combine data and procedures” (p. 432). Further to this, designers can deploy objects that operate as ‘icons’; an icon is an image that implies the set of instructions that have been assigned to that image (Murray 2012, p. 424). Icons visually suggest to users the action or outcome that a computer will execute. They assist users in understanding how to operate a system or artefact. Murray notes that we “should be able to see what the machine is doing – not by looking at the gears, but by understanding its behavior as determined by a logical system of cause and effect” (2012, p. 61). According to Murray, designers should aim to shape an artefact so that users can clearly comprehend how the machine operates and how it will respond to user commands.

In summary, Murray’s ideas relating to the procedural affordance of computing, provide foundational knowledge that describes some of the technical processes involved in digital design. For instance, designers may deploy objects and icons to help users understand how to operate and interact with an artefact. To further understand these concepts, particularly in relation to Murray’s ideas on interactive systems, attention must turn to analysing her theories on the participatory affordance. As Murray states, when designers

²⁶ Murray notes that this idea is not to be confused with “procedural” computer programming (2012, p. 434). The term ‘procedural’ can be used to describe “linear programming strategies” within computer science (p. 434). Murray, however, uses the term ‘procedural’ to describe an attribute of the digital medium.

are shaping interactive digital environments, they are working with both the procedural and participatory affordances of the digital medium (2012, p. 434).

3.4 MURRAY'S PARTICIPATORY AFFORDANCE OF THE DIGITAL MEDIUM

The participatory affordance of the digital medium describes ways in which designers can allow users to “manipulate, contribute to, and have an effect on digital content” (Murray 2012, p. 432). According to Murray, people who are using digital artefacts are required to perform “a kind of response to the ‘call’ of the machine” (1997, p. 127). Digital designers create interactive artefacts by shaping the actions of the computer within the procedural realm of the digital medium (Murray 2012, p. 434). They also shape the actions of users through engaging the participatory affordances of the digital medium (p. 432). The act of creating interactive artefacts, according to Murray, involves the procedural and participatory aspects of computing (p. 432).

Murray describes interactivity as an “instance of related behavior between two entities that are acting upon one another” (2012, p. 426). For Murray, digital interactivity involves “human actions and computer responses” (p. 426). According to Murray, an interactive outcome “cannot be a design goal in itself since there can be good and bad interactions between computers and humans” (2012, p. 12). She says that the “appropriate design goal for [those making] interactive environments is not the degree of interactivity, but whether or not the system creates the satisfying experience of agency” for the user (p. 12). It appears that Murray is not concerned with the level to which users are involved with interactive features; but rather, she focuses on the types of user experiences that are generated as a result of interactive designs.²⁷

According to Murray, agency is a positive user experience: it is the satisfying feeling that comes as a result of taking “meaningful action” and seeing the results of these “decisions and choices” (1997, p. 126). Murray’s theories suggest that designers *should aim* to create systems that allow users to experience the delight that comes from successfully operating, interacting with, and taking productive action within a digital system or artefact. She prioritises design processes that lead to users experiencing agency.

²⁷ Theorists and practitioners that specialise in children’s interaction design offer a different understanding of the notion of participation, in the context of the design of digital objects, systems and artefacts. For example, Alison Druin establishes a participatory design method that involves children in the design process; this process involves children as users, children as testers, children as informants and children as design partners (2002, pp. 15–27). Murray’s theories do not encompass the ways that humans participate in the design processes; she limits her study to assessing participation between a user and a system or artefact.

The Theoretical Framework

In her discussions on the participatory affordance, Murray does not explicitly identify the need for designers to consider the age of their intended audience. In the context of this project, it is important to acknowledge that the very notion of children's literature is one that is defined by its intended audience (Grenby and Immel 2009, p. xiii); issues relating to audience are central to the design of children's books. For example, picture books have historically been shared by a combination of adult and child readers (Nikolajeva and Scott 2006, p. 21). Adults commonly read picture books to children (Smeets and Bus 2013, p. 185). Through shared book reading, children can establish close social bonds with adults, and they can also be taught important cultural and educational information (Nikolajeva and Scott 2006, pp. 21–26; Smeets and Bus 2013, p. 185).

My research project involves users in both digital and non-digital interactive opportunities; it includes consideration of interactivity that can occur between a user and a digital artefact, as well as interaction that can occur between adults and children who are engaged in shared digital book reading. According to Löwgren, when an interaction design process involves non-digital interaction “the ideal scenario would see the establishment of a *multidisciplinary* design” approach (2014, emphasis in original). It therefore may be appropriate that within this project I have applied a designerly interaction design approach in addition to children's literary theory, in order to analyse the ways that book applications can foster social relations.

In summary, Murray's theories on the participatory affordance establish some central aspects associated with designing interactive artefacts. Potentially her ideas may be informed by further interaction design studies, as well as children's literature and cognitive science theory (Jung and Stolterman 2012; Nikolajeva and Scott 2006; Smeets and Bus 2014). This transdisciplinary approach may allow for a more thorough analysis of how designers can shape children's book applications, accounting for the social and educational outcomes that are affiliated with picture books.

3.5 MURRAY'S SPATIAL AFFORDANCE OF THE DIGITAL MEDIUM

Murray's theories relating to the spatial affordance of the digital medium revolve around the notions of "space" and "place" (2012, p. 439). In her discussions on virtual space, Murray refers to studies conducted by geographer Yi-Fu Tuan (2012, pp. 161, 172–74). According to Tuan, geographical space is untamed, it "lies open"; when space is enclosed and "humanized", it becomes "place" (1977, p. 54).

Murray's theories on digital space deviate from Tuan's foundational concepts. Where Tuan views space as being "open" with "no fixed pattern" (1977, p. 54), Murray conceives of it as being "fixed" (2012, p. 439). According to Murray, digital designers use the spatial affordance in order to create "a fixed landscape" (p. 439). In describing her idea of digital space, Murray states that it is "created by clearly distinguishing one place from another" (p. 439). Place, in this context, is a "differentiated area within a navigable space" (Murray 2012, p. 433).

Murray states that designers use both the spatial and encyclopaedic aspects of computing to provide users with the "experience of enclosure in [an] explorable, extensive" space (2003, p. 6). As a result of combining the spatial and encyclopaedic aspects of computing, designers can, according to Murray, provide users with environments that are immersive (2012, p. 425).²⁸ An immersive environment feels "expansive, detailed and complete" and for this reason users become "captivated" or absorbed by the activity that they are undertaking (Murray 2012, pp. 101–02). Murray states that when "we engage with an immersive [virtual] world and it responds to us as we expect it to, revealing deeper levels of content, greater detail in its coverage, we become more deeply immersed" (2012, p. 102). According to Murray, immersion "cannot be a property of an artefact"; it is "not a function of the size or volume of the stimulus", it is a measure of user "engagement" (2012, p. 101).

²⁸ The concept of immersion can be traced to poet and philosopher Samuel Taylor Coleridge's idea of "suspension of disbelief". Coleridge's idea encapsulates a particular audience experience where fictive entertainment is accepted as reality (1983). Games writer François-Dominic Laramée applied Coleridge's concept of suspended disbelief to an analysis of immersive game experiences (Salen and Zimmerman 2004, p. 450). According to Katie Salen and Eric Zimmerman, the concept of immersion can be described by the "immersive fallacy", where the "pleasure of a media experience lies in its ability to sensually transport the participant into an illusionary, simulated reality" (2004, p. 450).

Where Murray considers immersion to be a measure of user engagement (2012, p. 101), other theorists distinguish between the concepts of immersion and engagement. Jane Yellowlees Douglas and Andrew Hargadon, for example, draw connections between the ideas of immersion and engagement, yet they also differentiate between these user experiences (2000). Yellowlees Douglas and Hargadon suggest that Mihály Csikszentmihályi's notion of "flow" is one that encapsulates the ideas of both engagement and immersion (p. 158). Csikszentmihályi's idea of flow can be defined as the "experience of pleasurable absorption in a task that is neither too easy nor too challenging" (Murray 2012, p. 420). Flow is characterised by clear goals, a sense of control, concentration on an intrinsically pleasurable activity, loss of self-consciousness, and a distorted consciousness of time (p. 420).

The Theoretical Framework

When describing the formation of space and place, Murray adopts a user-centred approach. She focuses on usability and on the ways in which users can navigate and become immersed in a virtual environment. Murray centres her analysis of the spatial affordance on the navigational and immersive aspects of data-bases and digital gaming environments (2012, pp. 161–81).

Murray recognises that books and film can “portray space” through “verbal description or image” (1997, p. 79). She does not, however, explicitly examine how designers form these aspects of digital environments. Murray does not analyse what Jung and Stolterman call the “material qualities” and “making approach” (2012, pp. 646–47). Within their designerly, “artefact-oriented” methodology, Jung and Stolterman emphasise the “aesthetic and experiential qualities of digital artefacts” (pp. 648–49). In doing this, they establish a connection between the formation of the aesthetic aspects of a design and historical approaches to traditional design.

With Jung and Stolterman’s approach in mind, it may be useful, in the context of this study, to draw on further children’s literature research; studies that investigate the ways in which picture book authors and illustrators aesthetically shape narrative spaces (Nikolajeva and Scott 2006; Nodelman 1988). This literary approach may assist my analysis of the range of materials and methods that designers can use when making detailed narrative spaces for children. These studies may also help me to connect material and process-oriented digital practices with traditional methods of working, traditional methods that are connected to social, cultural and physical events and experiences.

In summary, Murray’s theories on the spatial affordance of the digital medium provide a useful starting-point that establishes the concepts of digital space, place, engagement and immersion. In the following case study analysis, it may be useful to also apply children’s literary theory relating to how picture book authors and illustrators use written words and imagery to create aesthetically driven narrative spaces for children. These additional theories may assist in forming clearer understandings of how book application designers can use narrative techniques and art and craft practices in order to imaginatively engage users in their work. It may also assist in connecting the practices used in book application design with wider social and physical concerns.

3.6 CHAPTER THREE CONCLUSION: THE THEORETICAL FRAMEWORK

Murray's affordances theories may provide a solid basis on which to undertake an analysis of the functional, user-centred aspects of digital design. For example, she examines ways that designers can provide users with encyclopaedic scope and detail. Murray analyses the ways in which objects and icons can be programmed so as to provide clarity for users. She assesses the ways that designers invite users to participate in interactive environments. Murray also addresses the concepts of space and place within digital design.

According to Murray, interaction designers "emphasize the fit between human actions and system [computer] responses" (2012, p. 426). Yet we have seen from the review of literature in the previous chapter that interaction designers may also adopt a designerly approach to human-computer interaction research and practice (for example, Löwgren 2014). This approach includes consideration of both the usability *and* the aesthetic qualities of digital systems and artefacts. Murray's ideas on the affordances of the digital medium have aesthetic implications, yet her studies do not investigate these aspects of design, nor do they acknowledge social considerations that can accompany aesthetic-driven analysis (e.g. Jung and Stolteman 2012). Through applying a transdisciplinary set of theories within this project, this may assist my analysis of the aesthetic materiality of children's book applications.

In order to answer my first research question, I have analysed Murray's theories relating what she calls the affordances of the digital medium. I conclude that, in order to use Murray's theories as a framework for the analysis of functional and aesthetic values of book applications, I must support her theoretical approach with wider transdisciplinary studies.

I will now turn attention to analysing the central case study, *The Fantastic Flying Books of Mr. Morris Lessmore* (Moonbot Studios 2011). In doing this, I apply a range of concepts, derived from children's literature and human-computer interaction theory, within Murray's theoretical framework.

4

Theory in Action A Case Study Analysis

In the previous chapter, I described and discussed Janet Murray's affordances theories. Murray provides a useful framework for a user-centred analysis of digital design. She studies the functionality and usability of digital systems and artefacts. Murray's theories may be seen to have aesthetic and social implications, yet these ideas are not fully explored in her research. Her theories may however be a useful framing tool in an analysis of young children's media-rich digital books.

My aim in conducting this research is to analyse theory, practices and techniques that specifically relate to the design of children's book applications; this includes addressing aesthetic considerations. In this chapter, I adopt Murray's affordances theories to provide a framework for analysis. I also draw on children's literature, cognitive science and further interaction design research with the view to establishing a deeper understanding of the functional *and* aesthetic values of book applications.

In order to further inform my research, I have adopted a case study, the children's book application *The Fantastic Flying Books of Mr. Morris Lessmore*. This work is designed for audiences aged four and above. Users download this application from an online store; it is then housed on their mobile computing device and they do not require Internet connectivity to experience the work.

The storybook contained in *The Fantastic Flying Books of Mr. Morris Lessmore* application was created in response to Hurricane Katrina, a natural disaster that affected southern regions of the United States in 2005 (Collier 2012). The story features a fictional narrative that is based on factual events. The protagonist, Morris Lessmore, survives a hurricane, finds himself in the wreckage of its aftermath and rebuilds his life in an abandoned library.

According to an article in *The Times*, “at some point in the future, a short children’s [application] called *The Fantastic Flying Books of Mr. Morris Lessmore* will be regarded as one of the most influential titles of the early 21st Century” (Machell 2011). This application has been described as “game-changing”; the designers have created a children’s book that combines “animation, inventive and playful interaction and quality content” (Donahoo 2011). The designers house a well-crafted digital story in a new, highly interactive format.

I will now apply Murray’s framework as an analytical tool to assist my observation of the design of this case study.

[For copyright reasons third party images have been removed from this section of the exegesis. The images were included in previous unpublished and examined versions of this work.]

4.1 RESEARCH QUESTION TWO

How may we apply Murray’s theories and theory relating to children’s literature to an analysis of the book application The Fantastic Flying Books of Mr. Morris Lessmore?

4.2 THE ENCYCLOPAEDIC PROPERTIES OF THE CASE STUDY

The encyclopaedic properties of the digital medium provide designers with computational “capacity” and consequently designers can provide users with a large quantity of detailed information (Murray 1997, p. 84). For example, the developers of *The Fantastic Flying Books of Mr. Morris Lessmore* have used the capacity of mobile devices²⁹ to provide users with an application that has two highly detailed parts. This work contains a storybook and a set of supplementary materials. The storybook is accessed when users touch a virtual leather-bound book depicted on the application’s homepage. The supplementary materials are accessed via a series of tabs that are visible on the left side of the homepage.

²⁹ *The Fantastic Flying Books of Mr. Morris Lessmore* application was originally designed for the Apple iPad hardware device (Moonbot Studios 2012). Current iPad models have the capacity to hold between 16 and 128 gigabytes of data (Apple Inc. 2015). *The Fantastic Flying Books of Mr. Morris Lessmore* application is 409 megabytes in overall file size.

The Fantastic Flying Books of Mr. Morris Lessmore storybook consists of a twenty-seven-page narrative told through written text, imagery and audio. This story contains high levels of detailed information relating to the protagonist, Morris Lessmore, and his response to a natural disaster. The supplementary materials in this application provide users with what Murray calls encyclopaedic “scope” (2012, p. 418). The supplementary materials include a short animated film, a short documentary film, links to online stores and hyperlinked materials. This application contains a broad spectrum of detailed information.

Due to the encyclopaedic properties of computing, designers can combine a range of media formats and genres (Murray 2012, p. 418). *The Fantastic Flying Books of Mr. Morris Lessmore*, for example, contains written text, animation, audio narration, sound effects, a musical score, play activities and interactive puzzles. The fundamental media components within this application are written text, imagery and audio.

According to Murray, when designers combine media, they also combine media conventions (2012, p. 415). I will now analyse the central media components of the case study, the text, imagery and audio, with the aim of assessing the ways the designers have shaped the media, and the associated conventions they have deployed.

4.2.1 The Encyclopaedic Qualities of the Written Text

The written text in *The Fantastic Flying Books of Mr. Morris Lessmore* is not incorporated into the central imagery; it appears at the bottom of the screen in a separate visual strip. The layout of the written text may be compared to the design of film subtitles.³⁰ Film and linguistic theorist Alexandra Assis Rosa notes that subtitles are designed to be “marginal” and as a consequence, they do not overtly attract audiences’ attention (1994, p. 318). The written text in *The Fantastic Flying Books of Mr. Morris Lessmore* is similar to subtitles in that the text appears in a marginal band underneath a central visual display. Potentially this approach to textual design may influence the levels of attention that users pay to this aspect of the artefact (Rosa 1994, p. 318).

The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* place the written text on a strip of colour that has minimal visual depth. There is an aesthetic contrast between the implied three-dimensional depth of the main imagery and the lack of visual depth in the textual band. Interaction designers Troy Innocent and Steward Haines describe this design approach when they say that text-based communications, within virtual environments, can be “overlaid on top of the [virtual] space”, and when this occurs, the text is

³⁰ Subtitling involves the on-screen appearance of written text; this text “translates” the verbal aspects of a film (Rosa 1994). This technique allows hearing-impaired viewers to understand the verbal component of an artefact; subtitles may also convert the verbal component of a film into another language (p. 318).

“not well integrated within the simulation of the world itself” (Innocent and Haines 2007). Within the case study, the designers have deployed two different visual stylistic approaches: one for the presentation of the written words; and another for the presentation of animated imagery. The text appears to be overlaid on the main imagery.

Nodelman highlights the problem that designers have in “relating the depthless space that words occupy to the implied depth of pictures” (1988, pp. 56–57). He poses a solution to this design conundrum: “the more representational pictures become, the more they need to be separated from the rest of the page by a frame or border” (p. 57). The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* separate words and imagery by deploying a frame with a border, as Nodelman recommends. This textual design approach may be viewed as one that highlights the material qualities of the text, as the textual quality is markedly different to the main visuals. Yet, as a consequence of this design technique, the words share more similarities with subtitles. The moving imagery that is featured in the main visuals invites users’ attention, the lack of textual integration has the effect of marginalising the written aspect of this application.

The designers also supply users with the option to hide the written text from view. In doing this, the designers have again drawn on protocols used in film-making. We should keep in mind that Murray acknowledges that digital designers can deploy a range of traditional design conventions and these conventions can have a variety of effects (2012, p. 25). For example, when there are no written words present in the case study, this artefact appears to share more similarities with an interactive film than a book. When the text is hidden from view, users experience the story by watching moving imagery and listening to audio (Sargeant 2013, p. 33).³¹

The design techniques deployed in this application, particularly the aesthetic construction of the marginalised band of text and the functional option that allows users to hide the text from view, have the effect of subordinating the written words. Murray states that designers need to consider the effects of deploying specific media conventions (2012, p. 25). By applying the film-making convention of subtitling, the designers of *The Fantastic Flying Books of Mr. Morris Lessmore* do not actively draw users’ focus to the written textual component of this application; subtitled text, and options that allow users to hide text, may result in users not focusing on the written textual aspect of this artefact. This reveals some of the socio-technical characteristics of this design. It is important within these discussions to keep in mind that picture books have historically been items that teach children how to read both text and imagery (Nodelman 1988).

³¹ *The Fantastic Flying Books of Mr. Morris Lessmore* story was first released as a short film; it was then developed into a mobile application, and was later adapted into a printed picture book. As a consequence of this story’s evolutionary track, it is not surprising that this work has strong filmic connections.

4.2.2 The Encyclopaedic Qualities of the Imagery

I will now analyse the second main media component in this application, the imagery. The visuals are dominated by the presence of computer-generated animation (Collier 2012). The designers have created this animated effect by hand-making and filming three-dimensional model sets; these are non-digital items. The animated component is primarily confined to character representations that have been digitally layered within the video footage of the background settings (Collier 2012).

In creating these visuals, the designers again draw on film-making conventions. They deploy visual framing techniques to direct users' attention to narrative detail. As Murray states, digital designers can make use of media conventions in order to direct users' attention to a task (2012, p. 415). Nodelman observes the ways that print picture book illustrators can direct readers' focus through using "close-ups" and other filmic framing devices (1988, pp. 179–84).

Ideas relating to framing techniques can be further understood through a study of scene three from the case study. Scene three begins with a close-up perspective of Morris Lessmore hooked to a lamppost that is being buffeted by strong winds. As the scene progresses, it shows a middle-distance perspective of the character hurtling through the air while holding onto the now uprooted lamppost. The scene concludes with a longer distance perspective: Morris Lessmore is running around the exterior of a house that is spinning in a column of cloud. This animated sequence displays the increasing intensity of the hurricane that occurs in the beginning of this story.

Smeets and Bus' findings support Murray and Nodelman's theories on how conventions can draw users' attention to a task. In studying the effects of animation on child users, Smeets and Bus conclude that, as animation attracts children's attention, it should have "relevance to the story" (2013, pp. 178-180, 2014, p. 3). Designers can harness the allure of animation and use film conventions in order to direct users' attention to important story detail. For example, in the previous analysis of scene three, I describe how the visuals portray the increasing intensity and the dangerous qualities of a natural disaster. This animated sequence directs users' attention to crucial story information. This design tactic is important to acknowledge, as this study revolves around a digital artefact in which narrative is a core component; it is important that children understand the story within a picture storybook (Smeets and Bus 2013). In this instance, the animated visuals support the telling of a story.

4.2.3 *The Encyclopaedic Qualities of the Audio*

The final media element used in this application is audio. This consists of narration, music and sound effects. Smeets and Bus' findings show that audio can be a "perceptually salient" aspect of a children's book application (2013, p. 180). Audio features in book applications can assist users in understanding the story. Smeets and Bus detail this idea when they say that, while reading digital books, young children tend to search for imagery that relates to the narrated story (pp. 179–80). Children attempt to match aural information with related visual data.

The relationship between the audio and imagery in a book application may be further understood through an analysis of the content in scene three. This scene is accompanied by audio narration that states: "The winds blew and blew". When users try to match the information supplied in the narration with the related visuals, as Smeets and Bus suggest they will, users may realise that this scene describes an unusually fierce, wind-related storm event. The narration cooperates with the visuals to reinforce the central narrative theme relating to the effects of a natural disaster. In this instance, the audio narration supports the visual content.

Smeets and Bus acknowledge that audio narration is standard in digital picture storybooks (2013, p. 176). Recorded narration is used in lieu of adults reading aloud to children (Smeets and Bus 2013; Yokota and Teale 2014). As a consequence, the audio narration in book applications commonly contains the same narrative information to that which appears in the written text.

Evaluation studies conducted by Mayer and Moreno identify students' responses to audio-visual presentations that contain text, animation and audio. Their results show that when designers place identical information in written text and audio narration, the text can become "redundant" (Mayer and Moreno 2002). This is known as the "redundancy effect" (2002). These studies reveal that human cognitive functions may not be able to process the high levels of visual information that are present, when written text and animation appear simultaneously within an audio-visual presentation (2002, p. 96). Consequently, when consuming these types of audio-visual materials, audiences commonly watch the animation, listen to the audio and ignore the written text (pp. 87–99). When all of the information in the text is repeated by the audio narration, the text tends to become redundant, and is commonly ignored by audiences (pp. 87–99). Mayer and Moreno's research is conducted on literate, as opposed to pre-literate, children.

Interestingly, children's literature research that focuses on pre- and semi-literate children reports similar findings to those of Mayer and Moreno. These literary studies identify that textual redundancy can occur when text and imagery present the same narrative information. For example, Nikolajeva and Scott state that, "when picture books depict words and images that provide 'duplicated'

information then the written word may become ‘redundant’” (2006, pp. 65–67). These literary scholars note that the “enumeration may seem redundant, since everything that the words describe is duplicated in the picture” (2006, p. 67). This type of picture book design, where the text and image reflect identical information, is called “symmetrical” design (Nikolajeva and Scott 2006, pp. 11–16).

We may extrapolate from Nikolajeva and Scott’s concept of symmetry, and apply it to the ways in which written text and audio narration operate in book applications. For example, the written text in scene three of the case study states: “The winds blew and blew”. The accompanying audio narration also states: “The winds blew and blew”. The narrative content is identical; as such, it may be labelled as symmetrical. The symmetrical design techniques displayed in *The Fantastic Flying Books of Mr. Morris Lessmore* may result in the text becoming redundant, as Mayer and Moreno suggest. Users may focus on the animation and the audio, and ignore the written component. The design standard whereby book applications have symmetrical written text and narration may raise concerns relating to child literacy. After all, picture books are used as central educational tools within child literacy development (Smeets and Bus 2013, 2014), and analysis of the case study suggests that the written text in this work may be considered redundant.

The audio component of *The Fantastic Flying Books of Mr. Morris Lessmore* also has a musical score and sound effects. The music that accompanies scene three is constructed from a synthesised orchestral loop featuring wind instruments and cymbal crashes. The choice of wind instrumentation lends support to the wind-related content featured in the written text, visuals and audio narration. The brassy staccato phrasing of the music establishes a feeling of unresolved tension. This suspenseful atmosphere is reinforced by sound effects that consist of thunderclaps and whistling winds. According to Smeets and Bus, audio features are “likely to elicit and sustain children’s attention” (2013, p. 180). In this instance, the designers of *The Fantastic Flying Books of Mr. Morris Lessmore* combine audio narration, music and sound effects to communicate a wide range of aural information about the severity and frightening nature of the storm event.

4.2.4 Summary: The Encyclopaedic Properties of the Case Study

Murray’s theories relating to the encyclopaedic qualities of computing assist in revealing the ways in which the designers of *The Fantastic Flying Books of Mr. Morris Lessmore* take advantage of the capacious nature of the digital medium. The designers of this application provide users with a detailed media-rich story and a broad spectrum of supplementary materials.

Murray's theories also help us to understand the ways in which designers form relationships between different media components in book applications. For example, the designers of the case study combine animation and audio (narration, music and sound effects) to communicate detailed narrative information regarding the storm event that occurs in the story. The designers also present duplicated information in the written text and audio narration in this application. In children's literature terminology, this can be called "symmetrical design" (Nikolajeva and Scott 2006, p. 11–16). Symmetry can lead to the text becoming redundant and to the text being ignored by readers (2006, pp. 11–16, 65–67).

Murray's theories on the encyclopaedic affordance also reveal the ways in which designers can combine media conventions. The designers of this application deploy film-making conventions, such as visual framing techniques, to draw users' attention to narrative content. Yet it is apparent that due to the use of filmic subtitling conventions, the written textual content is marginalised. As Murray states, designers need to be cognisant of the effects of using different media conventions. In this instance, the use of film-subtitling conventions may have the negative effect of reducing the levels of attention that users pay to the written text.

This analysis of the ways in which the case study designers use the encyclopaedic affordance of the digital medium raises issues around textual redundancy and the marginalisation of written text. These design techniques may have educational and social ramifications. I will now turn attention to 'procedural' properties of the case study. This may clarify the ways in which designers can program a system in order to shape and form a children's book application.

4.3 THE PROCEDURAL PROPERTIES OF THE CASE STUDY

According to Murray, the procedural affordance of the digital medium provides designers with computational processing power (Murray 2012, p. 434). Designers use this power when they program rules and system behaviours (p. 434). This idea may be evident in the opening sequence of *The Fantastic Flying Books of Mr. Morris Lessmore*. This application starts with a homepage that shows an image of a virtual leather-bound book. The designers program an animation to automatically begin five seconds after this page appears. The designers have programmed rules; in this instance, the system behaviours have been automated. When these rules are carried out by the digital system, users see an animation consisting of a leather-bound book, a pointing finger and text that says: "read".

Murray states that designers can use visible objects to make the workings of the machine clear to users (2012, p. 434). In programming the text-visual automated animation depicted on the homepage, the designers help pre- and semi-literate users to visually comprehend how they can interact with and operate this artefact. This appears to be an example of effective automated procedural design: touch the animated pointing finger and the leather-bound book will open, and the story will begin.

Not all aspects of this artefact are programmed to appear automatically, the designers also shape this work so that it responds according to user commands. For example, the animated objects shown on the homepage visually alert users to the fact that this is an interactive artefact. When users respond to the pointing finger icon by touching the animated area of the screen, the virtual book cover opens. This aspect of the work is interactive.

Murray states that when designers are shaping digital interactive features, they draw on users' "tacit knowledge" in order to make an artefact appear "familiar" (2012, p. 9). In shaping the interactive sequence that appears on the homepage, the designers rely on users' understandings of how printed books operate; open the book's cover and the story will be revealed. The designers, in this instance, use conventions derived from print book design in order to communicate with users.

The designers draw on further print book conventions when making the navigational aspects of this artefact. For example, a virtual piece of curled paper appears in the top right of the screen at the conclusion of each scene in this application. This visual cue is intended to inform users that it is time to turn the page. The skeuomorphic nature of this feature pays homage to the physical structures of printed books. The curled paper is a navigational signal that is familiar to users. Furthermore, when users touch the screen and swipe or flick their finger in a right-to-left motion, the machine responds by revealing the next page. Murray states that on an "electronic notepad, an animation may reinforce the model of turning a page" (2012, p. 61). The designers use a similar technique in *The Fantastic Flying Books of Mr. Morris Lessmore*. An animated page-turning sequence is programmed to play as users progress from one story location to the next. This page-turning operation draws on readers' experience of having turned paper pages in printed books. This familiar action is easy for most users to enact.

As previously noted, cognitive science studies show that children tend to focus on animated visuals (Smeets and Bus 2013, pp. 178–79). In programming an animation that features a virtual page that is turning, the designers of this application may draw users' focus to the processes involved in turning pages in codex books. The animated page turn may attract users' attention. By providing this animation, the designers may interrupt the visual flow of the story, and they may divert users' attention away from the narrative. Murray observes that this type of navigational aid makes the workings of the computer clear to the user (2012, p. 61). Yet this page-

turning feature may not be effective in assisting children to focus on the important task of understanding the story. In this instance, this skeuomorphic feature visually disrupts the graphical narrative content.

The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* also provide users with a menu icon. This cog-shaped icon is visible on the bottom right of the screen in each scene of the application. When users touch this icon, the application's menu is displayed. The menu houses options that enable users to mute the music and narration, turn off the text, and select from a range of ten language translations applicable to the audio narration. The designers have programmed this application so that users may tailor their sensory experience of the story.

The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* also deploy icons in the form of arrows. In Murray's terms, these arrows operate as logical, visible cues (2012, p. 434). They visually instruct users on how to successfully interact with the application's content. When users move their finger in line with the direction that the arrow is pointing, the machine responds by starting an animated sequence.

In Murray's terms, the arrows that operate in this application are "logical" (2012, p. 434). For example, when users track their finger across the screen, following the direction suggested by the arrows that appear in scene one of the case study, Morris Lessmore appears to be swept across a verandah. The more that users swipe their finger, the further Morris travels. The action of the user replicates the effects of strong winds. The visual action depicted in this scene moves in a logical direction, the same direction indicated by the arrow icon. In this way, the arrow may be viewed as being a logical, effective means of communication.

The arrow icon that appears in scene one has been aesthetically shaped to provide users with a visual help tool. Through deploying this arrow icon, the designers clearly communicate to users, pictorially informing them of the interactive gesture required. In Innocent's terms (2001), this use of iconography may be viewed as being an effective and efficient means of communication. The visual nature of this design makes it appropriate for an application that is intended for pre- and semi-literate users.

4.3.1 Summary: The Procedural Properties of the Case Study

In summary, this analysis demonstrates how the case study designers deploy print book conventions when programming the application's navigational features. Murray reminds us that some conventions used in traditional media serve a useful function in the digital realm, yet other conventions do not (2012, pp. 17, 23). For example, the designers program a simple, familiar page-turning

interaction pattern that is based on the actions required to turn a page in a printed book. This appears to be an effective design. However, the animated page-turning sequence in this application may distract from narrative content. This animation may reflect an ineffective use of a traditional design convention.

Murray recommends that designers should make the operations of the computer clear to users. The designers of this application, for example, deploy icons, such as arrows, to provide users with a level of visibility and clarity; they use icons as visual instructional communication tools.

This analysis has raised issues relating to the designers' use of media conventions and their use of icons. It has not, however, revealed information relating to the processes that the designers engaged in when programming these aspects of the application. These ideas will be further explored in the following chapter. I will now turn attention to the participatory properties of the digital medium. This is so that we can further understand the ways in which users can interact with and through a children's book application.

4.4 THE PARTICIPATORY PROPERTIES OF THE CASE STUDY

Murray's analysis of the participatory affordance of the digital medium revolves around the ways in which users interact with digital artefacts (2012, pp. 432–33). One way in which she judges the calibre of a design is based on the quality of the activities that users undertake (2012, pp. 12–13). This idea can be further understood through an examination of scene three in *The Fantastic Flying Books of Mr. Morris Lessmore*.

As previously described, scene three concludes with Morris Lessmore running around the exterior of a house that is being swept into the vortex of a tornado. At the conclusion of the scene, circular arrows appear on the screen. If users trace their finger in line with the visible arrows, a new animation sequence is triggered. When users interact with this image, they become involved in visual and haptic experiences; they view animation that has been triggered by their circular touchscreen gestures.

The designers shape the interactive features in scene three so that users can engage in sensory experiences that relate to the story; the circular touchscreen gestures may evoke associations with the spiralling winds that occur during hurricanes. Further to this, through engaging in touchscreen actions, users become active story participants: they become experientially involved in transforming visuals and revealing the effects of the storm event. As a result, this may be seen as an effective story-related interactive sequence.

Murray states that designers should be “well motivated” when scripting user participation. For example, if we examine some of the interactive activities in *The Fantastic Flying Books of Mr. Morris Lessmore*, the designers’ motivations may come into question. Some of the highly interactive puzzle activities in this application do not relate to the story. The issues surrounding this aspect of the design may be further understood through an analysis of the content in scene fifteen.

When interacting with the content in scene fifteen, users drag puzzle pieces across the screen in order to form a unified picture. This highly engaging activity is embedded in the narrative content, yet it does not inform the story. Instead of prioritising the story, the designers were perhaps motivated to showcase their design prowess alongside the opportunities afforded by mobile computing devices. In this instance, their design goals may not be, in Murray’s view, well motivated. Perhaps these activities might be less distracting if they were housed in the supplementary materials.

Smeets explains the effect on users when interactive activities are embedded within the flow of a book application narrative. She states that interactive activities can “entertain” audiences and therefore “increase children’s motivation, but [they] may also promote a ‘play-mode’ rather than stimulate children to read the entire story” (2012, p. 12). Game designer and theorist Ernest Adams further describes the effects of offering users high levels of interactivity within digital narrative environments. He states that interactivity “is almost the opposite of narrative; narrative flows under the direction of the author, while interactivity depends on the player [user] for motive power” (Adams in Jenkins 2004, p. 118). Analysis of the activities present in scene twelve of the case study may assist us in further understanding issues relating to user motivation, interactive features and narratives.

Through shaping the activity in scene twelve, the designers invite users to play a virtual keyboard. Users can learn the song *Pop Goes the Weasel*, or they can freely explore and play the musical keyboard that appears on the screen. This activity does not inform the story. This musical activity promotes play and, as such, users may be functioning in “play-mode”, as Smeets suggests. When users are engaged in this activity, their motivation is perhaps directed towards play rather than towards understanding narrative content. As a consequence of engaging with this activity, users may lose the stimulus to complete the story.

In this instance, the designers' inclusion of an unrelated, highly interactive activity may disincline, as opposed to stimulate, children to finish the story. Locke reminds us that adults should not hinder a child's sense of play (1996, p. 45). Yet in the context of a storybook, as opposed to a game application, perhaps there are methods that designers can deploy whereby play activities direct users' attention towards narrative content.

Murray states that rather than focusing on the levels of interactivity contained in an artefact, designers should aim to provide users with the pleasurable experience of agency (2012, pp. 12, 100–02). For example, users who engage in the musical activities presented in scene twelve may be able to freely express themselves, and as a result they may experience the sensation of agency. When creating a children's storybook application, however, perhaps designers should initially ensure that interactive features relate to and further inform the narrative, prior to or alongside designing for user agency. This recommendation does not preclude children from playing within a literary context. Rather, it is directed towards assisting children in comprehending and completing a story. Through learning to complete stories, children may experience the pleasure of being literate and of enjoying literature. Designers of book applications can potentially assist in making this literary experience playful.

The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* also use the participatory properties of the digital medium in order to shape the application's supplementary materials. These materials provide users with further interactive opportunities. These are in the form of links that connect to a series of stakeholder websites and online stores. Löwgren states that there are "ethical implications" associated with interaction design (2014).³² In designing Internet links for *The Fantastic Flying Books of Mr. Morris Lessmore*, the designers provide pop-up alerts that appear prior to connecting users to remote sites. These pop-ups inform literate users that they are about to navigate outside the application. This design tactic will not prohibit Internet access, but it provides a gateway between users and the World Wide Web; it may mitigate instances whereby pre-literate children unwittingly gain access to third party websites. It appears that designers need to be cognisant of the ways in which they can shape digital artefacts, to ensure that their content is appropriate for the age of their audience, keeping in mind that not all Internet sites are designed for use by young children.

³² The *Children's Online Privacy and Protection Act (COPPA)* is legislation enacted by the United States government. This act goes some way towards providing guidelines for, and limitations on, the design of children's digital content. All iPad applications are sold via the US-based App Store; therefore all developers of iPad applications are required to adhere to this act. This act is mainly focused towards controlling the collection of children's personal information, such as their full name, home address, email address, telephone number, age and hobbies (Federal Trade Commission, n.d.). Designers can collect user data through automated processes whereby they remotely locate, collect and store information that is housed within the users' device. Alternatively, developers can request that users enter personal information into an application's system. The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* do not request or collect user data. Yet it is important to note that there is legislation that guides the design of children's digital content.

When describing digital participatory elements, Murray does not detail the ways that these can foster social interaction. Conversely, Jung and Stolterman acknowledge that “material artefacts, as designed forms of technology, actively intervene in human life” (2012, p. 649). For example, my analysis of children’s literature research within previous chapters demonstrates the ways in which picture books can involve a “dual audience”; a combination of adult and child readers who engage in social interaction during shared book readings (Nikolajeva and Scott 2006, pp. 21–26).

Smeets and Bus state that interaction “with adults is still considered to be the optimal way to familiarize children with stories and the varied and rich vocabulary in picture storybooks” (2013, p. 176). Further to this, shared book reading strengthens emotional bonds between adults and children (2013, p. 185). Yet it is interesting to note that contemporary children’s digital books are not commonly designed to include adult participation (Smeets and Bus 2013, p. 178). For example, *The Fantastic Flying Books of Mr. Morris Lessmore* contains audio narration that ‘reads’ the written text. Pre-literate children do not require the work to be read to them by an adult.

The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* provide users with the option to mute the application’s narration. This setting option can be accessed via the menu. By muting the narration, an adult could read the work to a child. However, cognitive science studies reveal that users commonly prefer audio-visual, rather than text-visual, content (Mayer and Moreno 2002; Smeets and Bus 2013, 2014). Furthermore, applications are not widely considered to be a form of media that supports shared, intergenerational reading experiences (Smeets and Bus 2013, p. 185). As a consequence, the muted narration option may not be widely used. Smeets and Bus observe that adults do not commonly participate in shared reading of digital storybooks (p. 185).

Audio narration in book applications may be a convenient feature for educators and parents, as books that contain this feature can be read to children multiple times without the need for adult intervention (Smeets 2012, p. 9). Yet Smeets notes that “in the absence of a supportive adult electronic book reading may be less stimulating and outcomes may not be comparable with adult-child book sharing” (2012, pp. 9–10). The designers of *The Fantastic Flying Books of Mr Morris Lessmore* have created symmetrical written and aural texts; as a result, they do not foster the development of intergenerational social bonds, and they do not stimulate the educational outcomes that can stem from intergenerational interaction over books.

4.4.1 Summary: The Participatory Properties of the Case Study

In summary, Murray's theories relating to the participatory affordance of the digital medium provide a solid framework for a study of how users can become actively involved with book application content. Her theories focus designers towards providing users with a sense of agency. When non-narrative-related interactive activities are embedded within the flow of a book application's story, this may cause children to disengage from narrative content. Users may be motivated to play and as a consequence they may experience agency, yet these activities may result in users losing the stimulus to complete the story (Smeets 2012, p, 12). This study also demonstrates how an interactive activity can engage children in narrative content. Perhaps narrative-related interactive features may also provide users with a sense of agency. This is an idea that will be further explored in the following chapter.

In this analysis, we can also see the importance of identifying the age of book application audiences; there may be educational and social concerns surrounding contemporary children's digital literature. In particular, the design techniques used in the case study do not overtly encourage social interaction to occur between adults and children. It appears that although audio narration is a common feature in book applications, adult-child shared book reading is still more effective in fostering children's social and literary skills.

This analysis demonstrates a relationship between digital interactive features and narratives, as well as wider social concerns relating to children's book applications. I will now turn attention towards analysing the ways in which the case study designers form a sense of space and place within this application. This may help to strengthen an aesthetic perspective on book application design.

4.5 THE SPATIAL PROPERTIES OF THE CASE STUDY

Murray states that designers can shape digital environments by creating distinct places within an overall digital space (2012, p. 433). According to Murray, designers can shape distinct places in order to help users navigate and orientate themselves within an overall digital environment (2012, p. 189). We may further understand this idea through analysis of *The Fantastic Flying Books of Mr. Morris Lessmore*. The case study designers created a series of twenty-seven distinct story locations, or places, within the overall space of this application. An overview of the places contained in this artefact's story is evident in the book's table of contents. This table displays a visual list of thumbnail images, each image is linked to a scene from the application's story. This table of contents, as Murray suggests, may assist users in orientating themselves within this digital environment.

The designers also structure the spatial design of this application by supplying users with a homepage. The term 'home' in this context operates as a metaphor. Murray states that designers commonly use metaphors to suggest to users how they can "understand one thing by mapping it onto something else" (2012, p. 424). For example, a homepage operates as a virtual hub from which users can navigate to a range of locations within a digital environment.

The homepage in *The Fantastic Flying Books of Mr. Morris Lessmore* is the first page that users see. It contains an overview of the application's supplementary materials,³³ access to the story and access to the table of contents. In this instance, the designers use website design conventions; the concept of a homepage is derived from graphic techniques deployed when creating Internet-based virtual sites (Whitbread 2006, p. 38). It appears that this graphic design technique can be deployed in book applications in order to assist users to understand the spatial organisation of a virtual environment.

The case study designers have also formed, what Murray may call, distinct places within the story environment of this application. For example, in scene sixteen Morris Lessmore is depicted standing on typography. If users swipe the typographic text with their finger, an animated sequence is triggered. This animation displays the protagonist running along the top of a sentence. As the sentence concludes, Morris Lessmore appears to fall and he enters a distinct virtual place. I will now analyse the ways in which the designers use written text, imagery and audio to form this distinct place.

In making the distinct place depicted in scene sixteen, the designers shape the written text in a different manner to that seen in the remainder of the application. The text is not at the bottom of the screen; it is integrated into the overall visual design. The text is also animated. For example, the written text shown at the conclusion of the scene scrolls from a central point in the image to the left- and right-hand edges of the screen. The typography moves at a pace that makes it difficult to read the words; as a consequence, users may watch, rather than read, this text. This typography has a visual, rather than textual, function.

The imagery depicted in scene sixteen is distinct, in that it differs to that seen in the rest of the story. The visuals are constructed entirely from computer-generated imagery; the hand-made, three-dimensional settings that feature in much of the application are absent in this story location. The use of sepia tones in this scene also creates a contrast between this digital place and many of the other locations in this application. Furthermore, the imagery is constructed from a central bright light that is surrounded by animated

³³ On the left-hand side of *The Fantastic Flying Books of Mr. Morris Lessmore* homepage are a series of tabs, which allow users to access the application's supplementary materials. When users select a tab, extra content is revealed. This content includes: a short documentary film; links to other applications; language options (the book's text can be translated into ten languages); and hyperlinked credits.

text. Morris Lessmore appears to have 'fallen into' the book he is reading; he is immersed in a story. This is a non-realistic, dreamlike landscape. The minimalist setting is distinct from the realistic, detailed representational scenes that constitute the majority of this narrative environment. These visuals are distinct from the others depicted in this fiction.

The audio that accompanies the visuals in scene sixteen assist in further describing this virtual place. The music consists of a waltz constructed from synthesised piano accordion and percussion instrumentation. The style of waltz heard in the music is not orchestrally formal; the minimalist instrumentation and the simple melodic structure are more indicative of European folk music and folk dancing. The historical connection between waltz music and dancing lends support to the visuals shown in scene sixteen. The movement that the music implies reinforces the movement depicted in the animated visuals. The music collaborates with the visuals and helps form a rich sensory environment.

According to Murray, designers can also form digital places that provide users with a "memorable experience" (2012, p. 189). For example, users can navigate the protagonist around the visual setting in scene sixteen. When users tilt the hardware device, they are able to alter Morris Lessmore's position within the virtual landscape. In doing this, the designers provide users with access to the device's accelerometer and gyroscopic features. As a result, when users tilt the device, it appears that Morris Lessmore is flying in a virtual space constructed from typographic text. The designers shape users' experiences by allowing them to have a personal and direct effect on the visual content. The level of engagement that the user may experience as a result of them interacting with this content may lead to them being deeply engaged or even immersed in this part of the story. Consequently, this may become a memorable experience for the user.

Murray states that immersive experiences come as a result of users "testing out the imaginary world and seeing how responsive it can be and how deeply it is described" (2012, p. 103). For example, the case study designers deploy a variety of sensory means to describe and show the content in scene sixteen. The designers reward users by allowing them to become active within the storytelling experience. The space is encyclopaedically detailed and responsive to user movements. This scene operates as an example of what Murray calls a memorable immersive virtual terrain.

4.5.1 Summary: The Spatial Properties of the Case Study

In summary, this analysis demonstrates how the case study designers visually describe the spatial organisation of the application's story through using a table of contents. The designers also provide users with a visual overview of the application contents by supplying a homepage. In doing this, the designers borrow from techniques used in printed books and in website design.

This study also demonstrates how the designers use written text, imagery and audio to form a distinct place in the fiction. In doing this, the designers enclose users in a media-rich virtual location. By providing users with a location that is interactive and one that rewards user explorations, the designers form a story location that becomes a memorable user experience.

This analysis accounts for some of the aesthetic qualities of book applications. It does not, however, involve investigations relating to the practical methods that the designers deploy when making the virtual space of this fiction.

4.6 CHAPTER FOUR CONCLUSION: THEORY IN ACTION

In this chapter, I analyse a children's book application through the lens of Murray's theories. My analysis of the encyclopaedic properties of the case study demonstrates how designers can create a storybook and supplementary materials. These features provide users with story detail and a range of additional story-related audio-visual materials. This analysis also demonstrates how designers use film-making conventions, such as visual framing, and how they use audio to provide what Murray calls emotional value (2012, p. 348).

We also saw that designers can use subtitling techniques. This subtitled, aesthetic formation of the written words may contribute to the marginalisation of the textual component of a book application. This analysis demonstrates how the use of symmetrical media within picture books can lead to the text becoming redundant (Nikolajeva and Scott 2006). According to the redundancy effect (Mayer and Moreno 2002), people tend to watch visuals, listen to audio and ignore symmetrical text. It is important to remember, in these discussions, that picture books are items that are used to teach children how to read both text and images (Nodelman 1988). As such, it appears crucial that the written text in picture books does not become redundant or ignored.

Through this analysis, we also saw that the designers of *The Fantastic Flying Books of Mr. Morris Lessmore* have programmed the application so that some material is automated and other material is responsive to user interactions. In doing this, they deploy skeuomorphic print book conventions, such as page-turning features. These conventions make the processes of the machine clear to the user (Murray 2012). Some of these conventions appear to operate effectively. Others, such as the page-turning animations, may distract users from narrative content.

Murray's theories relating to the participatory affordances of the digital medium focus designers towards providing users with a sense of agency. This case study analysis demonstrates how play-based activities may lead to users experiencing agency. However, my analysis also shows how interactive activities can distract users from the story; users may become engrossed in play and lose the stimulus required to complete the book (Smeets and Bus 2013).

Murray's theories on spatial digital affordances provide a framework that reveals how designers can shape a sense of space and place within book applications. For example, the case study designers borrow from book and website design conventions to provide users with overviews of the application. These global perspectives of the work are in the form of a table of contents and a homepage. These structural guides may assist users in understanding the space of the application, and may help them to navigate the work.

My analysis of the case study also demonstrates how the designers present, what Murray may call, a distinct place. The designers construct a distinct place within this fiction by using animated text, computer generated imagery, and synthesised music. The designers also shape interactive features in order to provide users with a memorable experience. In the example analysed, the designers enclose users in a media-rich, distinct location, and they allow users to navigate the protagonist around this scene. The level of detail and the responsive nature of the scene may lead to users becoming immersed in this content.

Perhaps the most notable findings from this case study analysis relate to the social implications of interaction design. This analysis shows how the designers of *The Fantastic Flying Books of Mr. Morris Lessmore* in effect exclude adults from being active story participants. The designers do not deploy design techniques that foster social, intergenerational social interaction. This is despite the clear social and educational benefits associated with shared book reading (Smeets and Bus 2014).

In order to answer my second research question, I have applied a set of transdisciplinary theories to an analysis of the case study. As noted, my findings cover a range of issues associated with the functional properties of the case study. My results also show a level of analysis relating to wider social issues. This study of *The Fantastic Flying Books of Mr. Morris Lessmore*, however, does not

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encompass an assessment of the practical processes that the designers deploy when programming the application. Nor did it reveal the processes they use when forming the aesthetic qualities of the assets. When studying other designers' work, there can be, as in this case, a limited range of recorded and published data that informs these aspects of analysis.

In the following chapter, I turn focus towards analysis of my own creative work *How Far is Up?* Within this analysis, I build on the theoretical and technical insights that have emerged from this case study assessment.

5

How Far is Up?

The Creative Project

In previous chapters, I examined Murray's theories relating to computational affordances and properties, and applied them to a case study. In this chapter, I assemble the insights gained from these theoretical and case study analyses, and use them as a means of examining my own creative work, a book application called *How Far is Up?* Within this chapter, I examine the techniques and practices that I have used during the making process, with the aim of offering new knowledge relating to the design of children's book applications.

5.1 RESEARCH QUESTION THREE

How have the findings that emerged from the case study analysis informed the design of my own creative work How Far is Up? And has the process of making a book application revealed further insights into remediating the picture book?

How Far is Up? is a book application that features a fictional story primarily aimed at audiences aged four and five. The protagonist is a five-year-old child named Rusty.³⁴ Rusty is curious about distance and space. Accompanied by a dog named Buster and a mouse called Ting, Rusty embarks on a voyage to the outer reaches of our universe. Finding themselves in peril, shy Buster leads the trio safely home to Earth.

³⁴ According to Nikolajeva and Scott, "child readers prefer stories about characters of their own age or slightly older" (2006, p. 132). *How Far is Up?* features a five-year-old protagonist as this story is primarily aimed at an audience aged four and five.

When developing *How Far is Up?* I drew inspiration from two seminal creative works from last century: the short film *Powers of Ten* by designers Charles and Ray Eames (Eames and Eames 2010), and the visual narrative *Cosmic View: The Universe in 40 Jumps* created in 1957 by Kees Boeke (Charity n.d.). These works are based on the mathematical theory of the ‘order of magnitude’ (e.g. Asimov 1983). The *How Far is Up?* story is loosely based on this notion; this mathematical concept provides a structure for the characters’ trajectory through space. The story begins on the Earth’s surface and the action moves progressively away from this starting point as the narrative unfolds.

5.2 COMBINATIONS OF CONTENT: THE ENCYCLOPAEDIC PROPERTIES OF *HOW FAR IS UP?*

My case study analysis illustrates how designers can present a detailed linear storybook and a range of supplementary materials within a children’s book application. Similarly, the narrative detail in *How Far is Up?* is presented in a succession of story segments and the application also contains a range of information in the form of supplementary materials. These additional materials contain a short film version of the book, further facts about space objects, teacher’s notes, and credits. This application provides what Murray calls encyclopaedic detail and scope. Akin to what has been revealed in the case study analysis, I have made the *How Far is Up?* story using a blend of written text, imagery and audio. I will now analyse how the design of the case study and related theory have influenced my approach to shaping the relationship between these aspects of my application.

5.2.1 Encyclopaedic Qualities of the Written Text

In the case study analysis, it was revealed that the designers do not actively draw users’ attention to the story’s written text. I have formulated an alternative to this approach when creating the textual design in *How Far is Up?* According to Smeets and Bus, written words in picture books do not “attract much attention” (2014, p. 6). Children “fixate more than 90% of their time on the illustrations in picture storybooks while they listen to an oral reading of the text” (Smeets and Bus 2013, p. 179). It appears that pre-literate children pay more attention to words that are presented in aural, rather than written, form. When making *How Far is Up?* I aim to use techniques that might encourage users to further focus on written text. This is so that we can augment the ways that picture books can operate as developmental literacy tools.

Figure 3
Scene 7: *How Far is Up?*
I position the written text in close proximity to related imagery, forming an active visual relationship between words and images.



One technique that I have used to draw focus to written text in *How Far is Up?* involves integrating the words into the overall visual layout. This textual design technique is informed by children’s literature and cognitive science findings. Nodelman acknowledges that picture book illustrators can “amplify” the presence of text by integrating it into the visual organisation of the imagery (1988, p. 56). Furthermore, Mayer and Moreno state that designers can draw focus to written text by placing it in close proximity to the visual data that it relates to (2002, p. 93). I have responded to these theoretical and analytical findings by aesthetically integrating the words into the visual story within *How Far is Up?* I have also placed the words in close proximity to related visual data. For example, in Figure 3 the words relating to the Milky Way are positioned directly under the visuals depicting the Milky Way. Unlike the case study designers, I aim to establish a close relationship between words and imagery. It appears that this design approach may have the effect of attracting users’ attention to the written words.

5.2.2 The Encyclopaedic Qualities of the Imagery

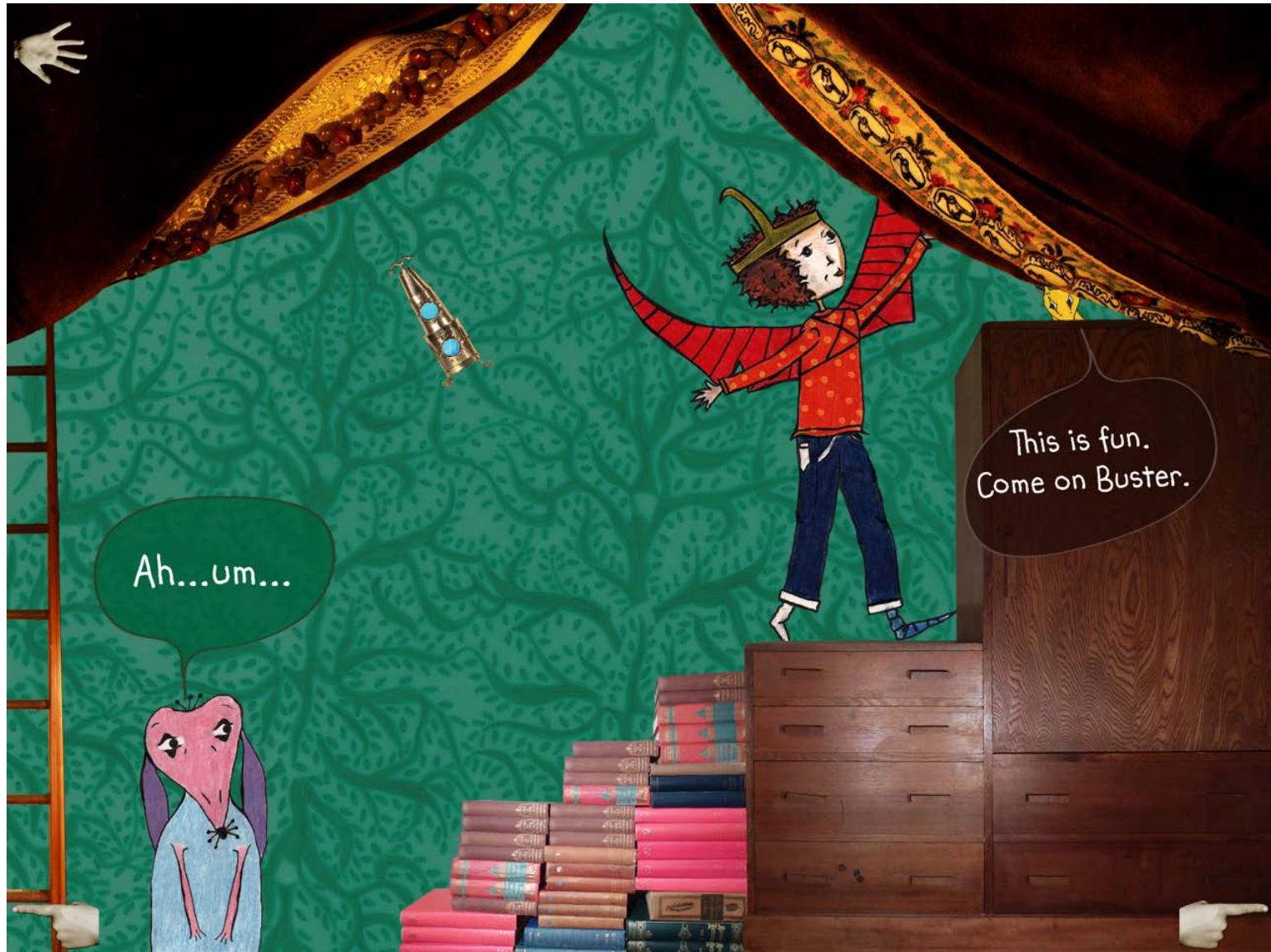
The visuals in *How Far is Up?* incorporate assets such as hand-drawn illustrations, original photography and NASA imagery. When making the application, I have combined these media elements into visual layouts. A layout can be defined as the order given to the information within a graphical design (Whitbread 2009, pp. 10–11). The layout depicted in Figure 4, for example, has been ordered in a specific manner; this layout houses animated sequences.

Murray states that when designers include media in their work, they also integrate associated media conventions (2012, p. 427). Nodelman notes that in film-making, scenes are often constructed from a number of different visual sequences (1988, p. 183).³⁵ This film-making technique is central to my design approach for the scene depicted in Figure 4. This scene incorporates three animated sequences.

The first animation featured in this scene depicts Rusty leaping onto a cupboard (refer to Figure 4). The second sequence shows Ting hiding. The third sequence displays Buster’s reluctance to join in the action. I intend to draw users’ attention firstly to Rusty, then to the top of the cupboard where Ting is situated, and finally to Buster who is on the floor below. I have used the allure of animation as a means of directing users’ attention around the scene. In doing this, I highlight the distances that exist between Rusty, the top of the cupboard and the floor. This design approach may have the effect of subtly directing users’ attention towards ideas relating to distance and space.

³⁵ Nodelman acknowledges that this differs from conventions used in print picture book making, where almost every successive picture “represents a different scene” from the story (1988, p. 183).

Figure 4
Scene 2: *How Far is Up?*
This layout houses animation. I use moving imagery as a means of emphasising ideas relating to distance and space.



When compared with the case study, *How Far is Up?* contains a minimal amount of moving imagery. Smeets and Bus suggest that although children's attention is drawn to animation, if too much movement occurs, children may not be able to process the information; they may be overloaded with visual information (2013, p. 180). As a consequence of viewing animation that is "crowded", children may not clearly comprehend the overall story (p. 180). With this in mind, I have drawn on the picture book convention of implied movement when designing *How Far is Up?*

Nodelman states that implied movement in picture book imagery may be compared to still frames in films (1988, pp. 171–84). Nikolajeva and Scott agree, stating that when print picture book illustrators imply movement, "the duration pattern of a picture is a pause" (2006, p. 159). Implied movement is the visual suggestion of action within a still image. This idea may be further understood by studying Figure 5. In this image, Rusty is shown to be mid-air in mid-action. The character appears to be paused.³⁶

According to Murray, designers should ask what purpose "conventions served in their original context, and if the underlying purpose is still valid" (2012, p. 427). For example, when illustrating Rusty for the image shown in Figure 5, I have focused on suggesting that this character is in the midst of undertaking a physical activity. I have visually suggested movement within this still image by depicting the character as being paused mid-action. My intention is to emphasise that within their investigations of 'up', the characters are engaging in increasing levels of action; this action eventually leads them to undertake interplanetary exploration. In this context, the picture book convention of implied movement maintains a useful purpose, as it has allowed me to use a still image to visually suggest an increased level of action and risk-taking; keeping in mind that although children's focus is drawn to animation, too much movement may prohibit young children from understanding all of the visual information supplied (Smeets and Bus 2013, p. 180).

³⁶ Scott McCloud notes the ways in which movement is depicted in static comic book visuals (1993). Yet as Nikolajeva and Scott state, comic books are a different form than the picture book; comic books maintain "a poetics of their own" (2006, p. 26).

Figure 5
Scene 2: *How Far is Up?*
This still image depicts Rusty in mid-air. When drawing Rusty, I implied movement. This image may be compared to a still frame from a cinematic scene.



5.2.3 The Encyclopaedic Qualities of the Audio Design

Cognitive science eye-tracking studies reveals that when audio narration describes an aspect of a digital book's visuals, children "fixate more often and longer" on the corresponding illustrated detail (Verhallen and Bus in Smeets and Bus 2014, p. 2).³⁷ I have drawn on these findings when designing *How Far is Up?* For example, the narration that accompanies Figure 4 states: "Up. The top of the cupboard". This narration may draw users' focus to the top of the cupboard where Ting is situated. Further to this, Ting and Buster are looking directly at each other. I have formed a visual line of focus between these characters, with the aim of directing users' attention from the top of the cupboard to the floor below. When users study the visuals in this scene and relate this information to the accompanying narration, as Smeets and Bus suggest that they will, users may learn about the distances between the characters Buster and Ting. I have deployed a combination of visual and audio means to emphasise an example of distance and space.

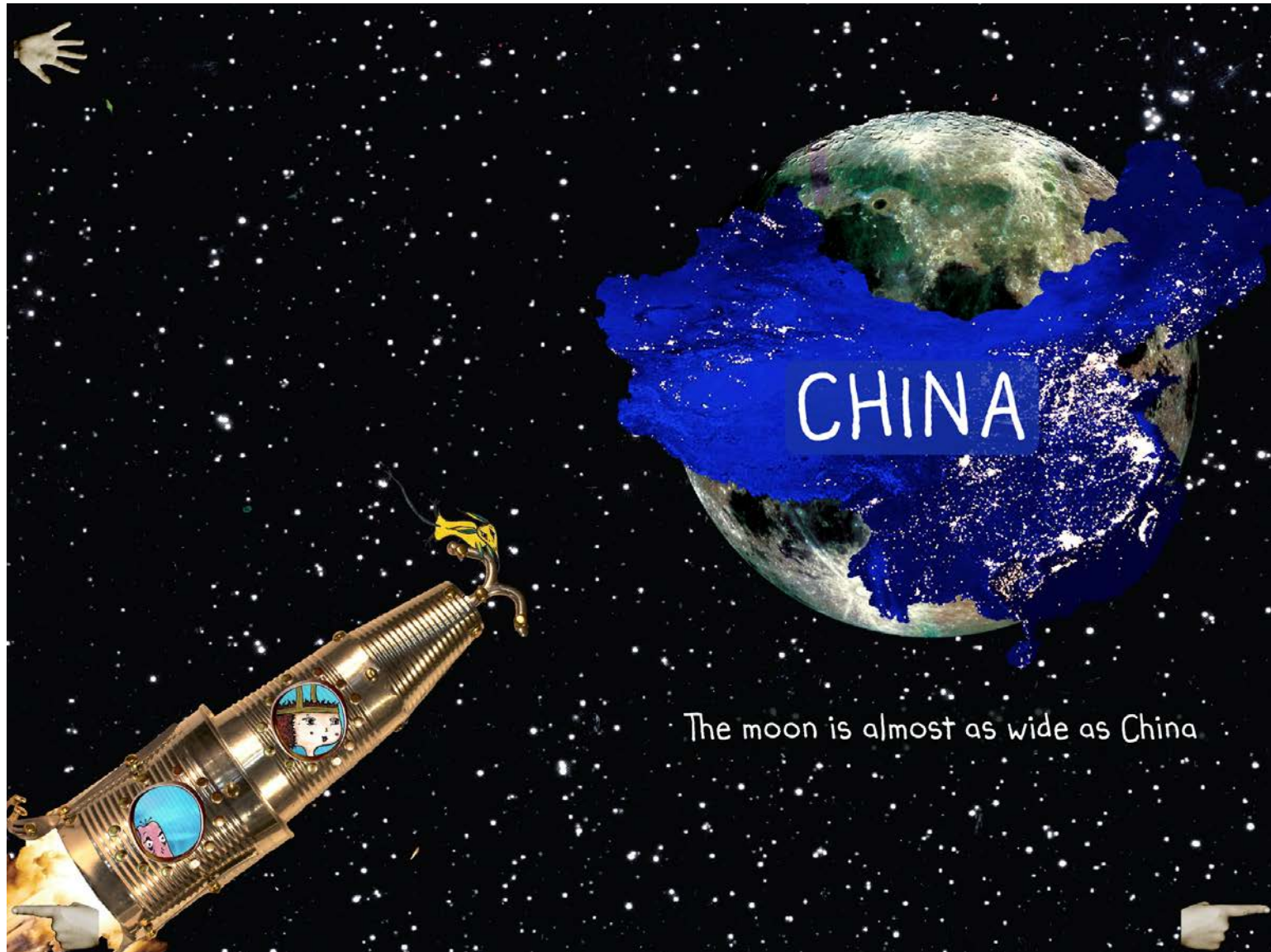
In my analysis of the case study, we saw that designers of book applications can create narration that directly reads the written content. It was noted that this style of symmetrical written text and audio might result in the written words becoming redundant. When designing *How Far is Up?* I have created written text that supplies different information to the audio narration. For example, Figure 6 contains written text that compares the size of Earth-bound landmasses with the size of the Moon. The accompanying audio narration states: "Up. Past the Moon". The text and audio narration contain different narrative information. With the aim of combating textual redundancy, I have established an alternative to symmetrical written and aural texts.

Nikolajeva and Scott's theories assist us in understanding how media can be combined in the context of a printed picture book (2006). They state that the words and pictures in picture books can convey separate messages (pp. 17–18). These media components may contain different information; when combined, this information can convey a unified story (Nikolajeva and Scott 2006, pp. 17–24). This technique, whereby words and images convey different narrative messages, is called "counterpoint" (p. 17). The concept of counterpoint is central within my design approach to *How Far is Up?* I will now analyse my use of counterpoint techniques.

The scene depicted in Figure 6 shows how I have counterpointed the three structural components of text, imagery and audio narration. Most notably, the written text and audio narration are not symmetrical, as previously stated. The text and audio contain different narrative messages: the written text is factual, whereas the narration features fictional information.

³⁷ There are advantages to presenting visual and aural information simultaneously. People tend to process these kinds of information using both visual and aural cognitive processes. This leads to what is known as "dual coding" (Paivio 1986; Smeets and Bus 2014, p. 2). According to dual coding theory, when information is processed simultaneously using both visual and aural channels in the brain, the message is processed more effectively than if it is processed through only one of these channels (Paivio 1986).

Figure 6
Scene 6: *How Far is Up?*
The text and audio narration
supply different narrative
information; they are
counterpointed.



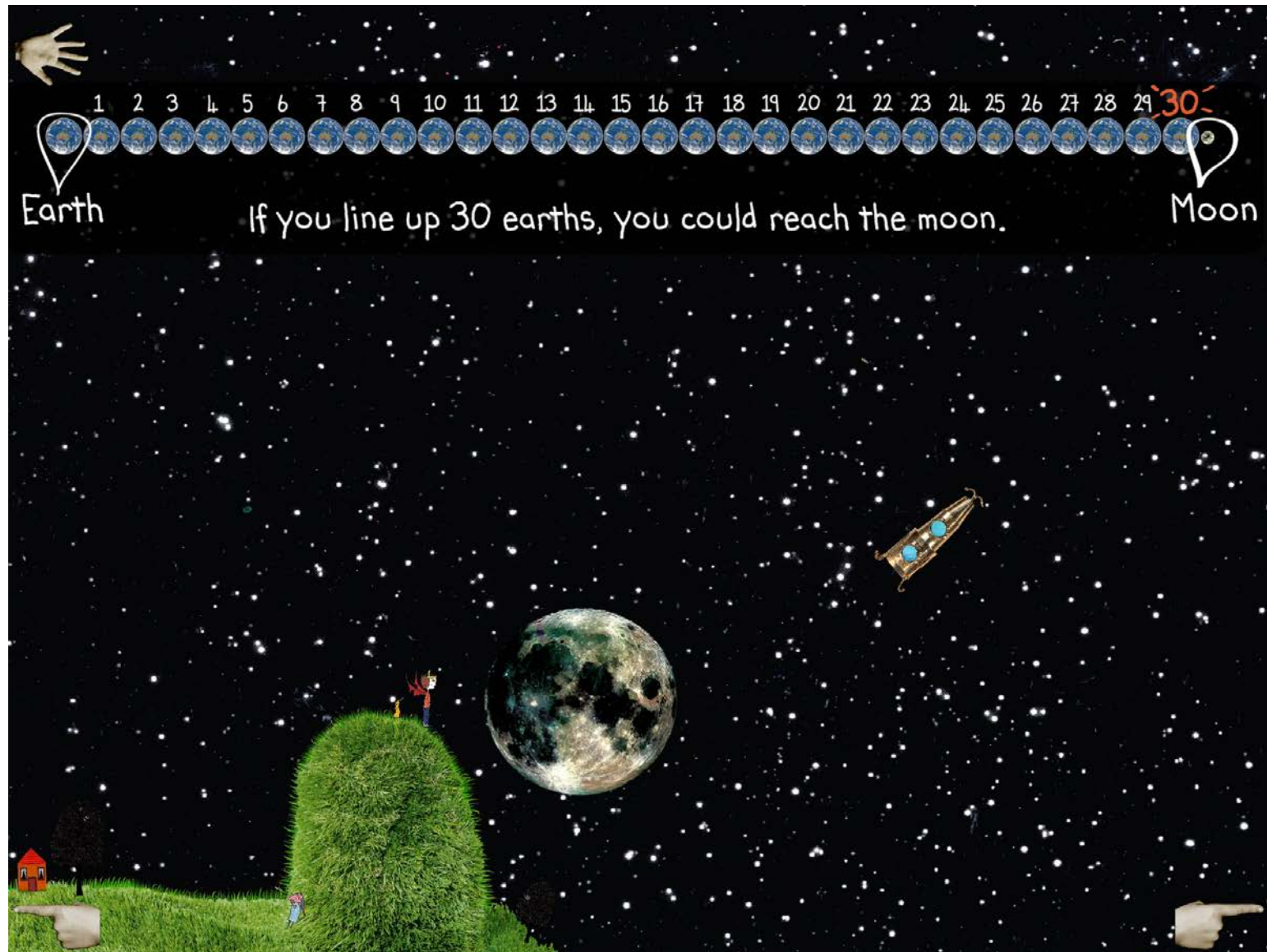
The idea of counterpoint may be further understood through an analysis of the *imagery* and *narration* in Figure 6. The illustrations in this image depict Rusty, Buster and Ting undertaking a haphazard space mission; Ting is holding on perilously to the outside of the rocket, and Buster appears to be a frightened, reluctant voyager. These visuals display chaotic humour. However, when narrating this scene, I have maintained a calm, detached tone of voice. The narration is orderly, matter-of-fact and serious in tone. The visuals and narration contain different narrative information; furthermore, the text and narration operate on two different stylistic levels. Nikolajeva and Scott might label this excerpt as being an example of counterpointed style (2006, p. 24). When combined, these contrasting narrative styles may coalesce and further inform users' understandings of the characters' exploration of distance and space.

The notion of counterpoint may have its roots in theories proposed by literary philosopher Roland Barthes. Barthes' ideas, relating to print journalism, describe how words and accompanying imagery can contain what appear to be separate messages (1977). He states that "the unity of the message is realized at a higher level, that of the story" (p. 41). When describing this concept Barthes explains that "analysis must first of all bear on each separate structure; it is only when the study of each structure has been exhausted that it will be possible to understand the manner in which they complement each other" (p. 16). These foundational ideas further describe the ways that counterpointed media elements, such as text and imagery, can cooperate in telling a picture book story, and how audiences may contribute to forming meanings from engaging with counterpointed media.

When describing the relationships between the different media elements in picture books, Nikolajeva and Scott note that authors and illustrators can also use a "triad" technique (2006, p. 112).³⁸ They state that counterpointed triad features produce a "multidimensional sense of the characters and their relationship[s]"; through deploying these techniques, practitioners can communicate "a good deal of information" (p. 112). I have adopted what may be labelled a triad technique in *How Far is Up?*

³⁸ Nikolajeva and Scott use this idea to describe the relationships between written text, line drawings and full colour pictures within a specific print picture book (2006, p. 112). In this study, I extend this concept and apply it to an analysis of the relationships between written text, imagery and audio in book applications.

Figure 7
Scene 5: *How Far is Up?*
The written text, imagery and audio narration contain counterpointed narrative information. They form a triad relationship.

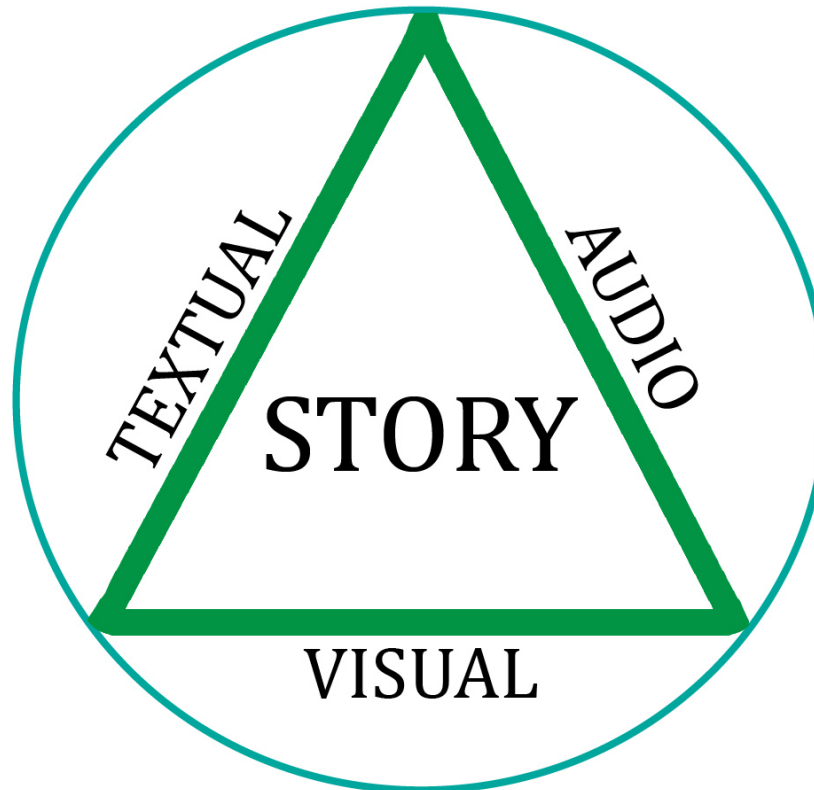


My use of what can be called triad technique is apparent in the scene depicted in Figure 7. The written text in this scene explains the distance between Earth and its moon. The imagery displays the fictional action of the characters, and it shows factual space objects. The audio narration serves as a documentation of the characters' progression through space. In this instance, the narrator states: "Up. As far away as clouds". The three structural components, written words, imagery and audio narration, offer users different sets of narrative information. Together, this triad of text, imagery and audio form a multifaceted, yet unified story about distance and space. This use of a triad notion differs to Nikolajeva and Scott's concept; they use the term to describe contrasting elements that are present in imagery and text. By applying this notion to digital picture books, we may further understand how designers can use the full potential of each media element to tell a cohesive, detailed story.

The positive effects of deploying a triad technique are demonstrated in cognitive science findings. According to Mayer and Moreno, the best levels of comprehension are achieved when audiences receive animated and narrated information, and when text is used to further describe the central topic (2002, pp. 93). As evident in my analysis of Figure 7, I have designed *How Far is Up?* in accordance with these findings. It appears that, by deploying triad techniques whereby text, imagery and audio each impart separate, yet complementary sets of narrative messages, designers of children's book applications can effectively communicate a highly detailed story. Using a triad technique, as opposed to a symmetrical design approach, designers can present a more richly described narrative.

Within this research, I adapt Nikolajeva and Scott's concept of a triad technique, and apply it to the ways in which counterpointed textual, visual and audio content can operate in book applications (refer to Figure 8). When engaging with a triad design, users may study the information present in each individual media component. The power of the triad is revealed when users combine the information presented and formulate deeper meanings. As Barthes states, "the unity of the message is realized at a higher level, that of the story" (1977, p. 41). In this context, when triad elements coalesce, they communicate a story relating to distance and space travel.

Figure 8
The Counterpointed
Triad Technique.
Textual, visual and audio
content can impart
counterpointed narrative
information.



5.2.4 Summary: Combinations of Content

This analysis demonstrates how the properties of computing allow designers to combine written text, imagery and audio in order to present narrative detail and scope. For example, when making *How Far is Up?* I have integrated the text into the visual layout and placed the written words in close proximity to related visual data. Through deploying this design technique, I aim to draw users' attention to the written text.

In accordance with Murray's theories, I have drawn on a range of media conventions when making *How Far is Up?* For example, I have deployed graphic design approaches when forming visual layouts. I have used film-making techniques in order to direct users' attention towards specific narrative detail. Finally, I have used the picture book convention of implied movement, to assist in minimising my use of moving imagery, keeping in mind that too much animated movement can lead to young children being visually overloaded (Smeets and Bus 2013, p. 180).

This analysis of *How Far is Up?* focuses on my use of counterpoint and triad techniques. In this project, I extrapolate from Nikolajeva and Scott's notion of a triad and apply it to the design of textual, visual and audio content in book applications. I propose that the counterpointed triad technique may operate as an alternative to symmetrical design approaches. As a result of deploying this technique, the written words, imagery and audio can impart different narrative messages. Consequently, designers may be able to communicate a rich and varied amount of narrative data. In deploying this technique, designers may more fully realise the storytelling potentials of the digital medium.

I will now apply the case study findings, relating to procedural properties of the digital medium, to an analysis of *How Far is Up?*

5.3 PROGRAMMING A BOOK: THE PROCEDURAL PROPERTIES OF *HOW FAR IS UP?*

My case study analysis did not demonstrate the underlying practical methods that the designers deployed when programming their application. A study of my own working methods during the process of making *How Far is Up?* may reveal more insights into this area of design. According to Murray, even "for those who will not be doing the coding, understanding how computer science describes objects and processes is crucial to making sound design decisions" (2012, p. 52). I did not write the code for the *How Far is Up?* application. I used *Demibooks Composer Pro* as the central software tool when designing this application. One of the key materials that interaction designers use when shaping objects and computer processes is software (Jung and Stolterman 2012, p. 647). I will now analyse my use of software in the design of *How Far is Up?*

I worked with a range of software suites when preparing the *How Far is Up?* assets prior to importing them into the Demibooks platform. For example, I used the *Adobe* suite of programs to produce portable network graphics (PNG) files. I used this format to store still images or single frames associated with an animated sequence. Each PNG asset in *How Far is Up?* has a transparent background. I also used the *Adobe* suite in order to make Joint Photographic Experts Group (JPEG) files. This format was for images that did not require a transparent background; the JPEG format does not support transparency. The content in a JPEG file is compressed, as a result, a final JPEG file size can be smaller than that of a comparable PNG asset. JPEG files can have the

advantage of being smaller in size, which in turn reduces the overall file size of the application; but this file type does not support transparency within a graphic image.⁴⁰

In addition to the *Adobe* software suite, I used the program *Ableton Live* to produce audio assets. These assets were exported from *Ableton* in MP3 file format. I used *Final Cut Pro* to produce video assets for *How Far is Up?* These assets were exported and housed in MP4 file format. The terms MP3 and MP4 are shorthand for ‘MPEG’, an acronym for Moving Picture Experts Group; the numbers refer to versions 3 and 4 of this file format. Finally, I used the platform *Your Fonts* to help create the handwritten typeface that is featured throughout the application.

The process of programming *How Far is Up?* involved organising a range of application assets. In doing this, I established what Murray calls a classification scheme (2012, p. 413). According to Murray, “file names, folders, and systems that clearly delineate file types” are “crucial within this aspect of the design” process (2012, pp. 203–05). When making the assets for this application, I created a consistent set of naming rules. For example, a file associated with this application could be named “01AnRBT09”; this label identifies that the asset is: affiliated with the first scene (01); it is an animation file (An); it contains the characters Rusty, Buster and Ting (RBT); and it is the ninth file of the animation sequence (09). As Murray recommends, I have consistently applied this classification scheme. This has allowed me to delineate between the large quantities of assets contained in this artefact.

Murray states that when creating a classification scheme, designers should pay close attention to identifying the individual detail of each file (2012, p. 413). For example, the format of each asset in *How Far is Up?* is evident in the suffix of the file name. A file may end in ‘.mp3’, which identifies the asset as being an audio file. Yet this suffix does not identify whether the asset contains music, sound effects or narration. Therefore my classification scheme also contains abbreviations such as: “An” (for animation), “Vid” (for video), “Mus” (for music), “SFX” (for sound effects), “Nar” (for Narration), “Txt” (for text), “Im” (for still images), “Set” (for setting) and “Bg” (for Background). According to Murray, by controlling the vocabulary used within classification schemes, this provides “precision of reference and retrieval” (2012, p. 415). By having a detailed classification scheme, I can swiftly identify crucial aspects of each asset by simply looking at the file name.

⁴⁰ Many application designers aim to reduce the overall file size of their artefact. This is in order to make an application easy to download from the Internet and easy to store on a mobile device. Many mobile computing systems have a reduced storage capacity when compared to desktop or laptop computing systems. As a consequence, designers often deploy methods that minimise file sizes. Version 1.2 of the *How Far is Up?* application is 379 megabytes in overall size.

As noted by Murray, designers can apply behaviours to digital assets (2012, p. 434). We saw in the case study analysis that the designers' programmed automated and interactive system behaviours. When making *How Far is Up?* I have engaged in programming processes that resulted in similar automated and interactive outcomes. For example, when making the scene depicted in Figure 9, I have assigned thirty-eight actions applicable to assets and system functions (refer to Figure 10). One such action involves automation. As a result of programming this system function, the action that occurs in Figure 9 is directly followed by the action that occurs in the next story location (depicted in Figure 11). My aim in automating this action is to propel this point of the narrative. I have "accelerated" the action (Johnson 1974), directing users towards an important point in the story where night falls and the characters consider the idea of space travel. This programming has an effect that is similar to the film-making technique of editing; I have digitally accelerated the action with the aim of maintaining users' focus on the narrative.

Figure 9
Scene 4: *How Far is Up?*
As soon as the action in this scene has concluded, the machine displays the following scene. In this instance, the action is automated.



Figure 10
 Scene 4 Workbench:
 Demibooks Composer Pro.
 When shaping this scene, I
 assigned thirty-eight
 behaviours applicable to
 assets and system
 functions.

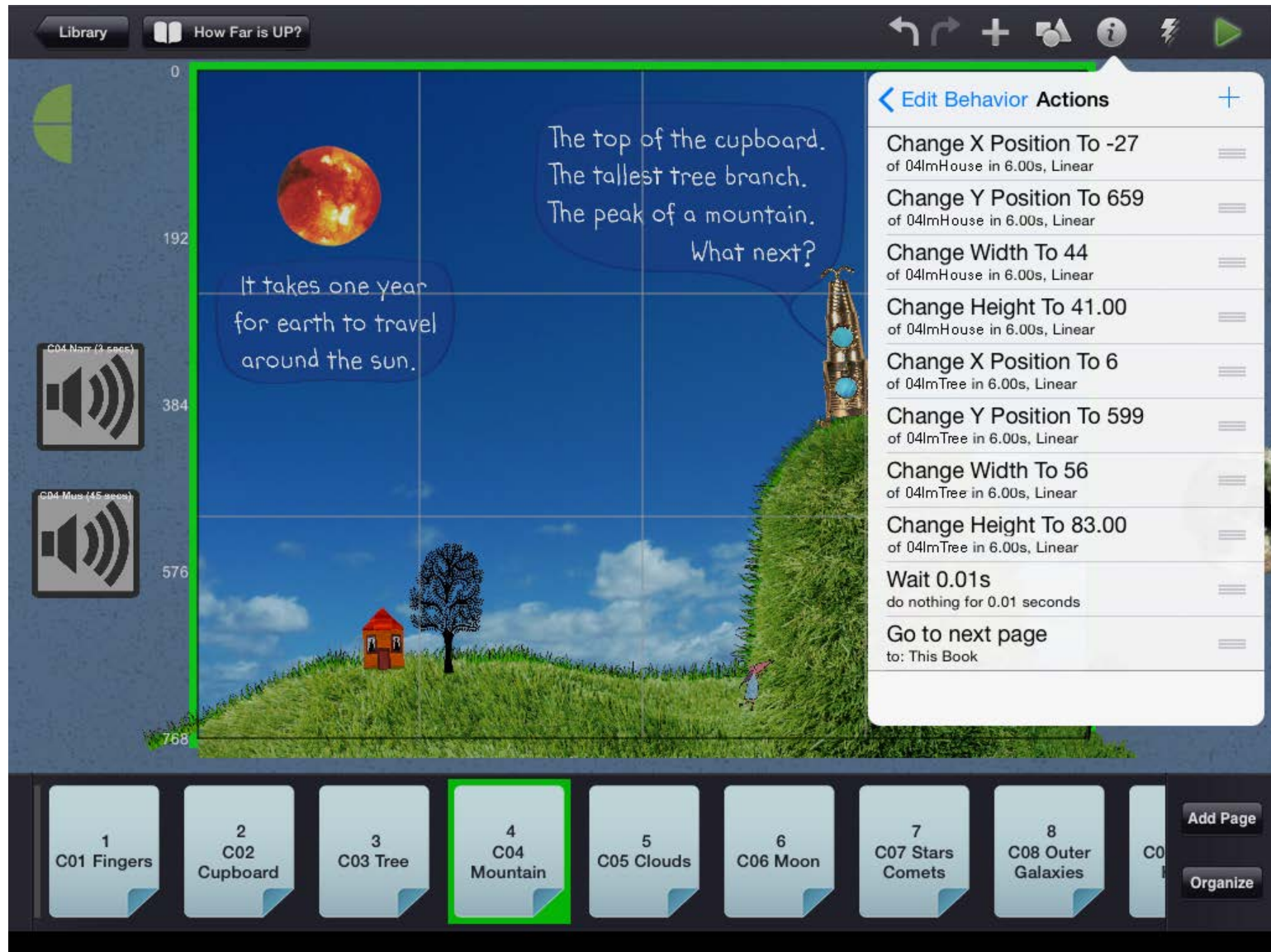
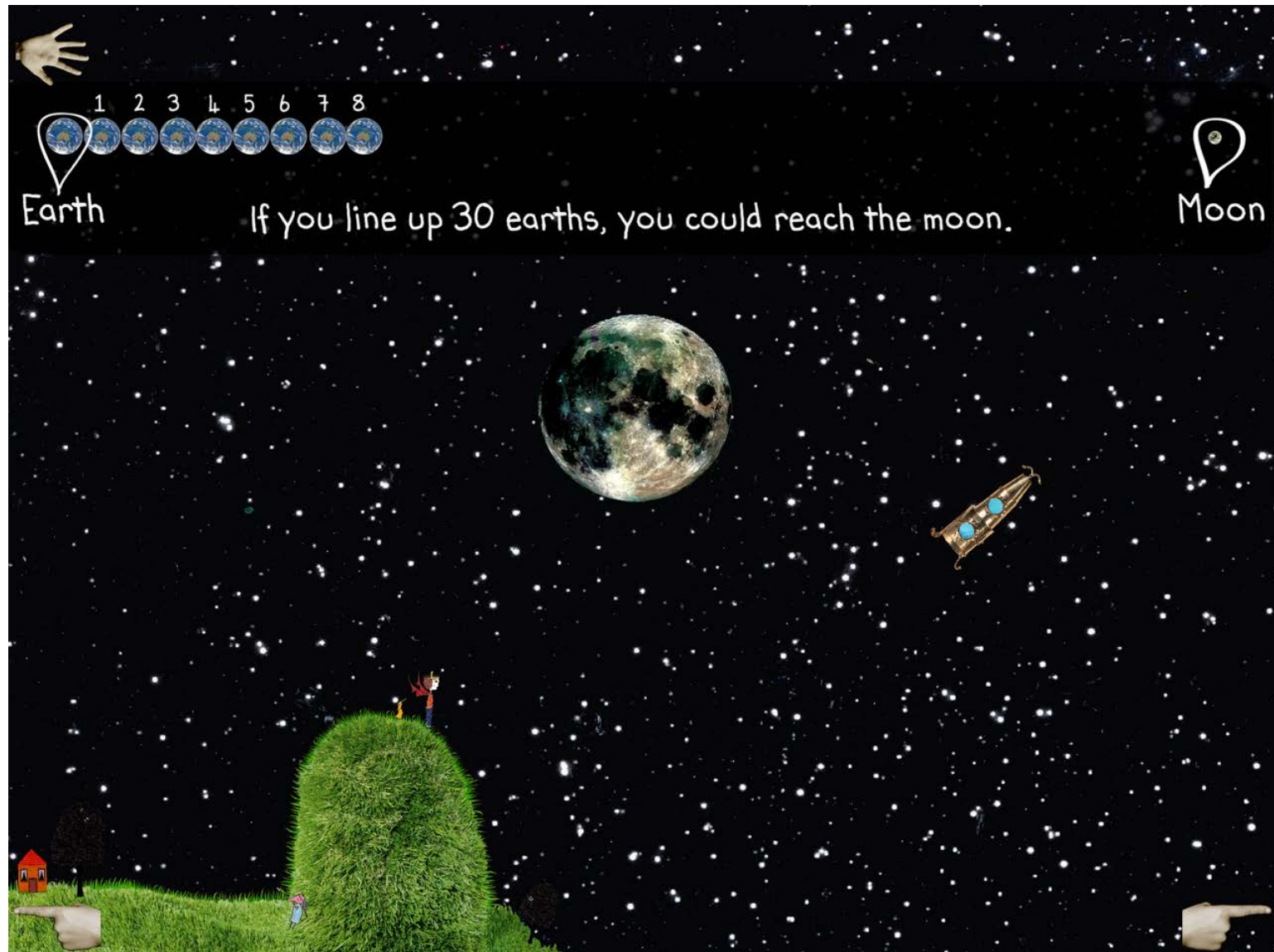


Figure 11
Scene 5: *How Far is Up?*
In automating a page turn,
I accelerated the narrative
action in order to direct
users' attention to the
story information
depicted in this image.



Designers also program behaviours that relate to objects (Murray 2012, p. 434). For example, when designing the scene depicted in Figure 12, I have positioned the 'rocket' object in a specific location on the screen. This location is known as "X(-224) Y(518)". Within software created for the design of digital assets, the screen area can be divided into a measured grid, as visible in Figure 13. In this example, the left corner of the rocket object is located on the measurement known as "-244" along the horizontal (or X) line of the screen. This object is also located on the measurement known as "518" on the vertical (or Y) line of screen.

Having positioned the rocket in the desired on-screen location, I then programmed a series of twenty-four individual rules and behaviours that alter the length, width, position and rotation of the rocket object over time (refer to Figure 14). The result is that the rocket appears to fly around an image of the Moon (as seen in Figure 12).

Figure 12
Scene 6: *How Far is Up?*
I positioned the rocket object in a specific location. I then programmed this object so that it appears to fly around an image of the Moon.

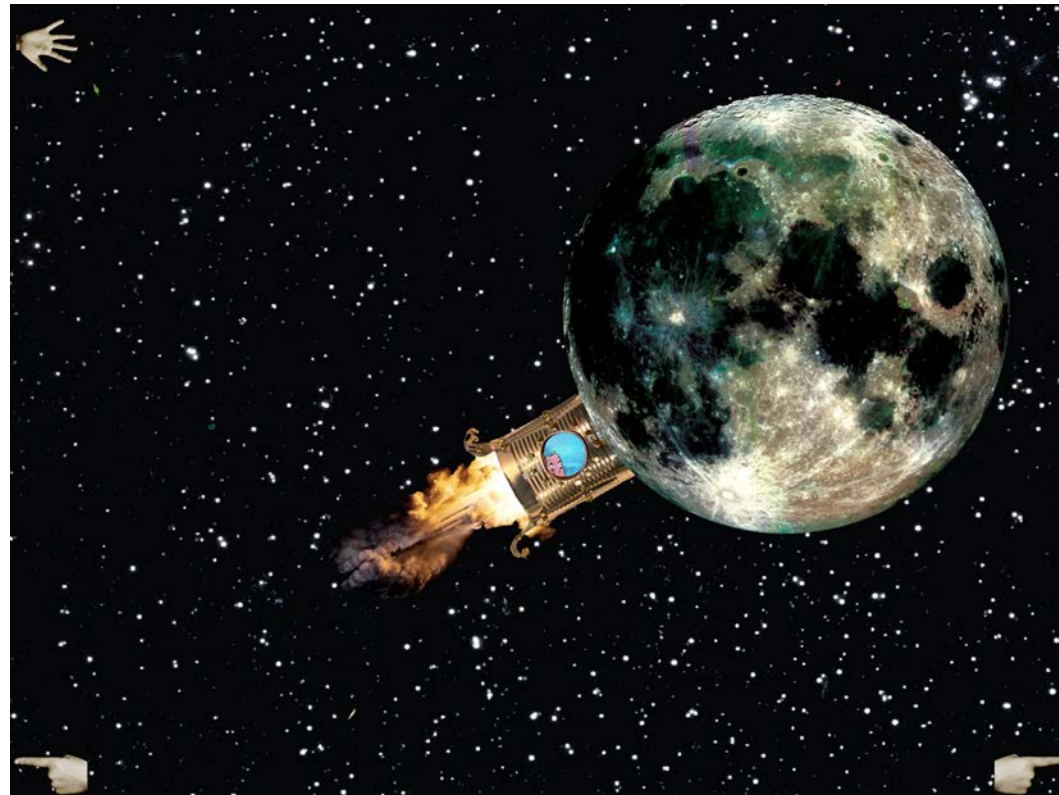


Figure 13
 Scene 6 Workbench:
 Demibooks Composer Pro.
 I positioned the rocket
 object in a specific location
 on the screen. I then
 programmed a series of
 behaviours and applied
 them to this object.

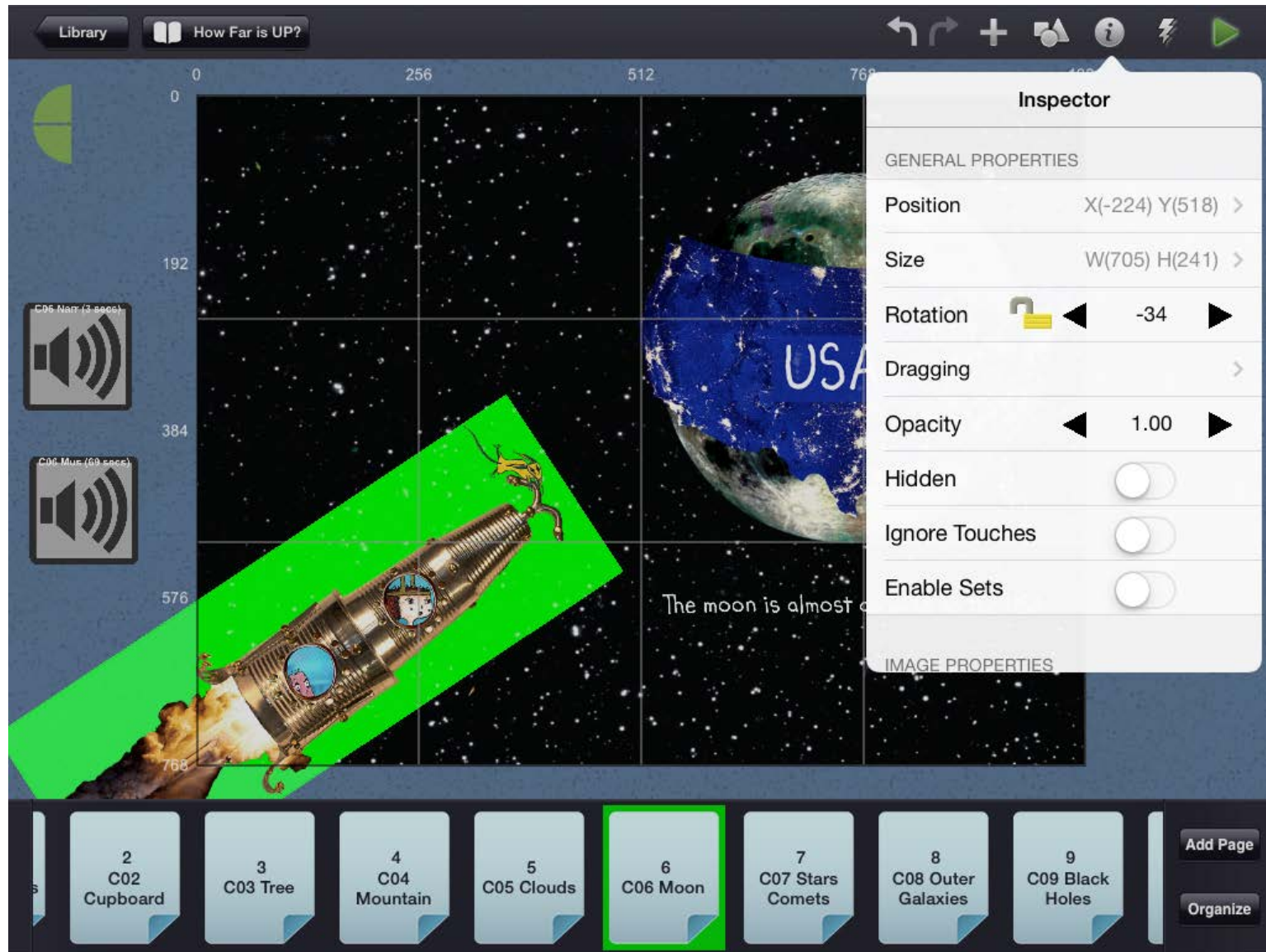


Figure 14
Scene 6 Behaviours:
Demibooks Composer Pro.
I programmed a series of
behaviours applicable to the
rocket object.



According to Murray, within the procedural affordance of computing, designers aim to make the “processing of the computing machine clear” to the user (2012, pp. 434, 444). Through analysis of the case study, we saw that the designers deploy arrow icons in order to communicate with users. Consistent with this idea, I have created a ‘pointing finger’ icon within *How Far is Up?* For example, in Figure 15 a finger icon is situated beside the characters. I designed this directional pointer in order to visually inform users that this scene involves interactivity.

The finger icon, which is situated beside the characters in Figure 15, has been animated. This animation involves looped imagery in which the finger icon alternates between appearing and disappearing from view. I have used the allure of moving imagery to draw users’ attention to this specific area of the screen. I have also deployed a directional pointer in order to visually suggest to users that they may touch the screen. As Innocent says, user interactivity “makes an icon an active agent in communication” (Innocent 2001, p. 255).

When programming the scene depicted in Figure 15, I have specified instructions that result in users being able to move the rocket object around the scene. In doing this, I utilised the device’s gyroscope and accelerometer components. I have tailored the design so that the rocket object responds in accordance with the angle of the iPad. As depicted in Figure 16, I have specified the velocity and viscosity of the rocket’s movements. This involved programming the physics of the rocket object: its motion through space and time. The physics parameters in *Demibooks Composer Pro* are labelled as being “weight”, “forces” and “collisions” (refer to Figure 16). In assigning values to the object’s parameters, I have specified the manner in which the object travels through the space of the scene over time.

Figure 15
Scene 1: *How Far is Up?*
The finger icon that is situated
beside the characters visually
informs users that this scene
involves interactivity.

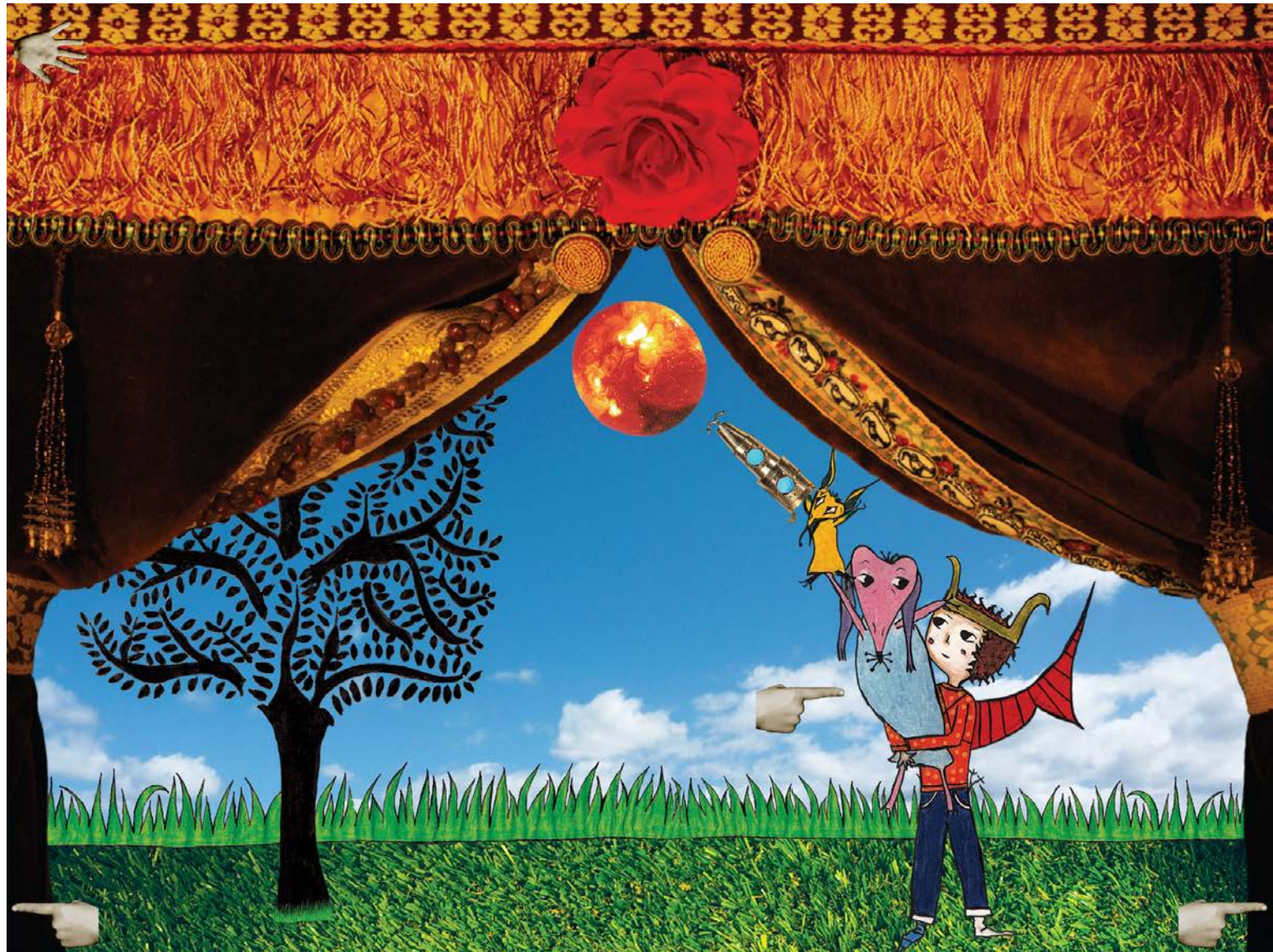
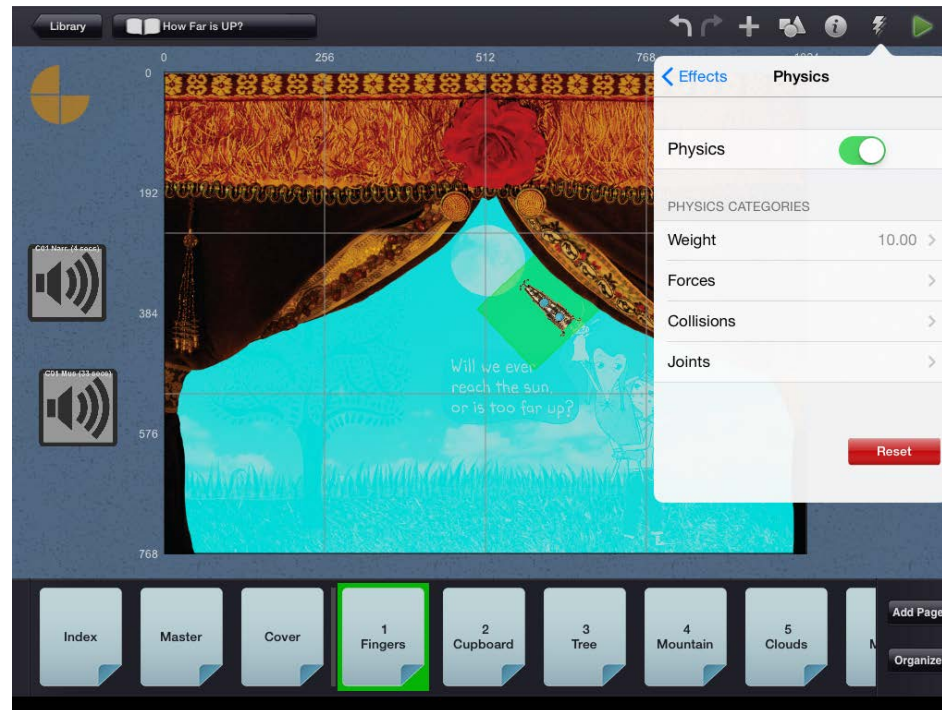


Figure 16
 Scene 1: Workbench
 Demibooks Composer Pro.
 I programmed the rocket's
 motion through space over
 time.

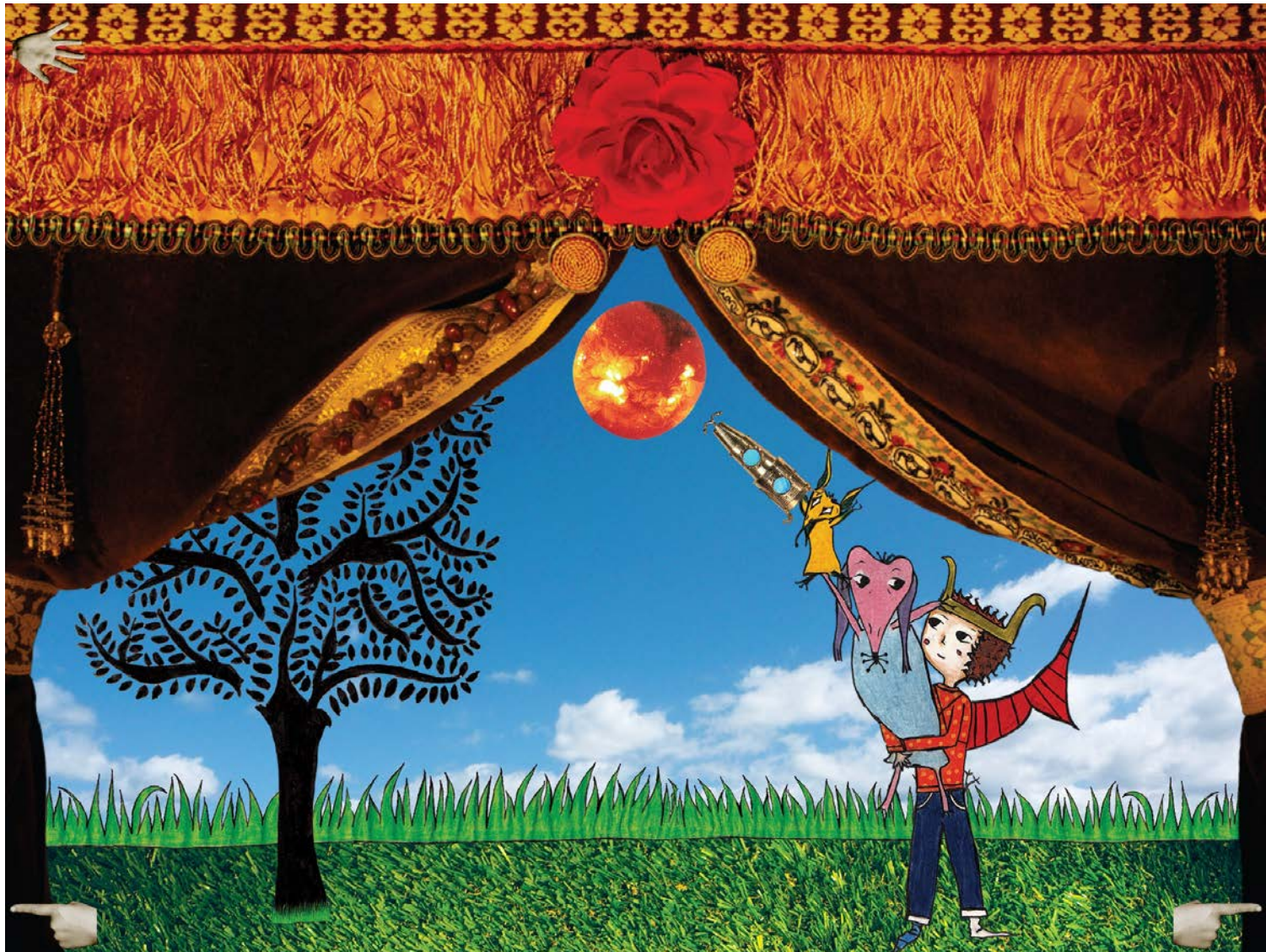


Murray suggests that when shaping a digital artefact, designers can draw on users' tacit knowledge (2012, p. 426). For instance, the case study designers create navigational tools that rely on users' knowledge of how to operate printed books. When shaping *How Far is Up?* I have relied on a different set of prior user experiences.

As depicted in Figure 17, finger icons are visible on the bottom left and right of the image. When users touch these icons, the machine responds by displaying the previous or following page. This design technique draws on conventions deployed in game design whereby arrows are used to navigate within virtual environments.⁴¹ I have used iconised directional pointers to provide users with clear visual instructions on how to navigate and operate this book application. In Murray's terms, I have provided users with visible cues.

⁴¹ In a game context, navigational arrows on computer keyboards, gaming consoles or touchscreens communicate information to players on how they can proceed up, down, left or right within a navigable game environment.

Figure 17
Scene 1: *How Far is Up?*
The page-turning navigation is visible on the bottom left and right of every scene. This is in the form of pointing finger icons.



When designing *How Far is Up?* I have also programmed application options that control audio features. To an extent, users can select how they will sensorially experience this artefact. For example, as seen in Figure 18 I have provided a menu that allows users to mute or unmute the application's music.⁴² According to Smeets and Bus, audio features that allow users to mute music have the effect of making book applications “more adaptive to support learning in different target groups” (2013, p. 181).⁴³ I have designed the menu so that it allows users to mute or unmute the music according to their individual needs.

Figure 18
Menu: *How Far is Up?*
The menu allows users to adjust audio features.



⁴² This menu also provides access to an overview of the book's contents.

⁴³ Smeets and Bus state that some children, who operate on specific learning spectrums, find music in digital books to be distracting (2013, pp. 180–81). Children who operate on an average learning spectrum, however, can find music evocative; audio can assist these users in maintaining their focus on a story (p. 180).

5.3.1 Summary: Programming a Children's Book Application

In summary, I have used Murray's theories on the procedural properties of computing to illuminate some of the technical processes involved in forming my application's assets.⁴⁴ In making *How Far is Up?* I have been able to uncover information relating to software and to the processes involved in forming and naming the application's assets. For example, I created a classification scheme so as to order, and be able to clearly identify, the digital files that constitute this artefact. This analysis provided more detail than what was revealed in my case study analysis. My analysis of *The Fantastic Flying Book of Mr. Morris Lessmore* did not reveal the software and naming protocols that the designers used.

Murray's theories also illuminate processes involved in programming the behaviours of assets and system functions. This analysis demonstrates how I have programmed the physics of digital objects; an object's movement through space over time. It is also clear that I have deployed operational and navigational icons that rely on users' tacit knowledge of digital gaming functions. By programming clear, consistent navigational and functional operations, users may, as Murray suggests, be able to successfully interact with this artefact.

I will now apply the case study findings, relating to the participatory properties of the computing, to an analysis of *How Far is Up?*

5.4 BEING INVOLVED: THE PARTICIPATORY PROPERTIES OF *HOW FAR IS UP?*

Through the case study analysis, we saw the ways in which the designers of *The Fantastic Flying Books of Mr. Morris Lessmore* invite users to engage in highly interactive features and how these can interfere with the flow of the story. Smeets and Bus recommend that interactive activities in book applications should relate to the story (2014, p. 3). I was cognisant of Smeets and Bus' findings when making *How Far is Up?* When designing for interaction I adopted a different approach to that seen in the case study. My approach may be further understood through an analysis of the content in Figure 19.

When users touch the screen in the scene depicted in Figure 19, the rocket object appears to fall from the tree. In designing this scene, I have specified that the rocket object can move in accordance with the angle of the device. The rocket can also move outside the confines of the screen. As a consequence, when users tilt the device, this can result in the rocket disappearing from view; if users

⁴⁴ It may be important to reiterate that Murray's concept of procedural design is different to the act of procedural computer programming (2012, p. 434). Murray uses the term procedural to describe a functional property of the digital medium. I acknowledge that this creates a dual meaning for this term, and may cause confusion.

reverse the tilt action, the rocket will reappear, as if, in the interim, it was floating outside the perceived space of the fiction. When engaged in this activity, users are involved in navigating an object around a virtual environment. This provides users with a proprioceptual⁴⁵ experience of distance and space. This is a story-related interactive activity.

Figure 19
Scene 3: *How Far is Up?*
The rocket object in this scene moves in accordance with the angle of the device. This activity provides users with an experience that relates to distance and space.



⁴⁵ Proprioception is the process by which humans vary their bodily movement and physical position in response to, or in relation to, a sensory or experiential occurrence.

The designers of *The Fantastic Flying Books of Mr. Morris Lessmore* use a variety of methods to alert users to the presence of interactive activities within their story. One such method involves the appearance of arrow icons. I have adopted a similar technique within some aspects of *How Far is Up?* as evident in my previous analysis of pointing finger icons in this application. I have also included an alternative technique for the presentation of interactive activities.

When designing this application, I have included what may be called unsignposted features. For example, the excerpt shown in Figure 20 contains a play activity. This activity is not accompanied by a signpost; I have not used a pointing finger icon to alert users to the presence of this feature. Yet if users track their finger across the scene depicted in Figure 20, particle images appear (refer to Figure 21).

Users may discover the particle activity during their first encounter with this application. Alternatively, users may only locate it on subsequent encounters with the artefact. Some users may never discover this activity.⁴⁶ In not signposting this playful aspect of the design, I have consciously elected to supply users with content that rewards exploration, keeping in mind that picture books are items that are often read multiple times (Merritt and Hass Dyson 1992, p. 101). This design technique is intended to help maintain users' engagement with the application across numerous encounters with the work. Locke reminds us that: "Curiosity in children...is but an appetite after knowledge and therefore ought to be encouraged" (1996, p. 93). In *How Far is Up?* I have provided users with hidden features that reward playful exploration.

Further to this, the particle activity shown in Figure 21 is placed at a potentially frightening point in the story. Four- and five-year-old children may fear the idea of black holes. This activity is intended to encourage users to associate this scene with ideas relating to fantasy and play. This visual effect may remind users that although the application contains facts, it is a work of fiction, an unrealistic story in which a child can travel in a tin-can rocket to outer space and view black holes. Black holes are factual objects; the characters' proximity to black holes is presented in a fictional manner so as not to overtly frighten young audiences.

⁴⁶ It is not essential that users locate the particle activity. Children may still understand the *How Far is Up?* story even if they do not discover this aspect of the work.

Figure 20
Scene 9: *How Far is Up?*
This scene contains an
unsignposted interactive
activity.

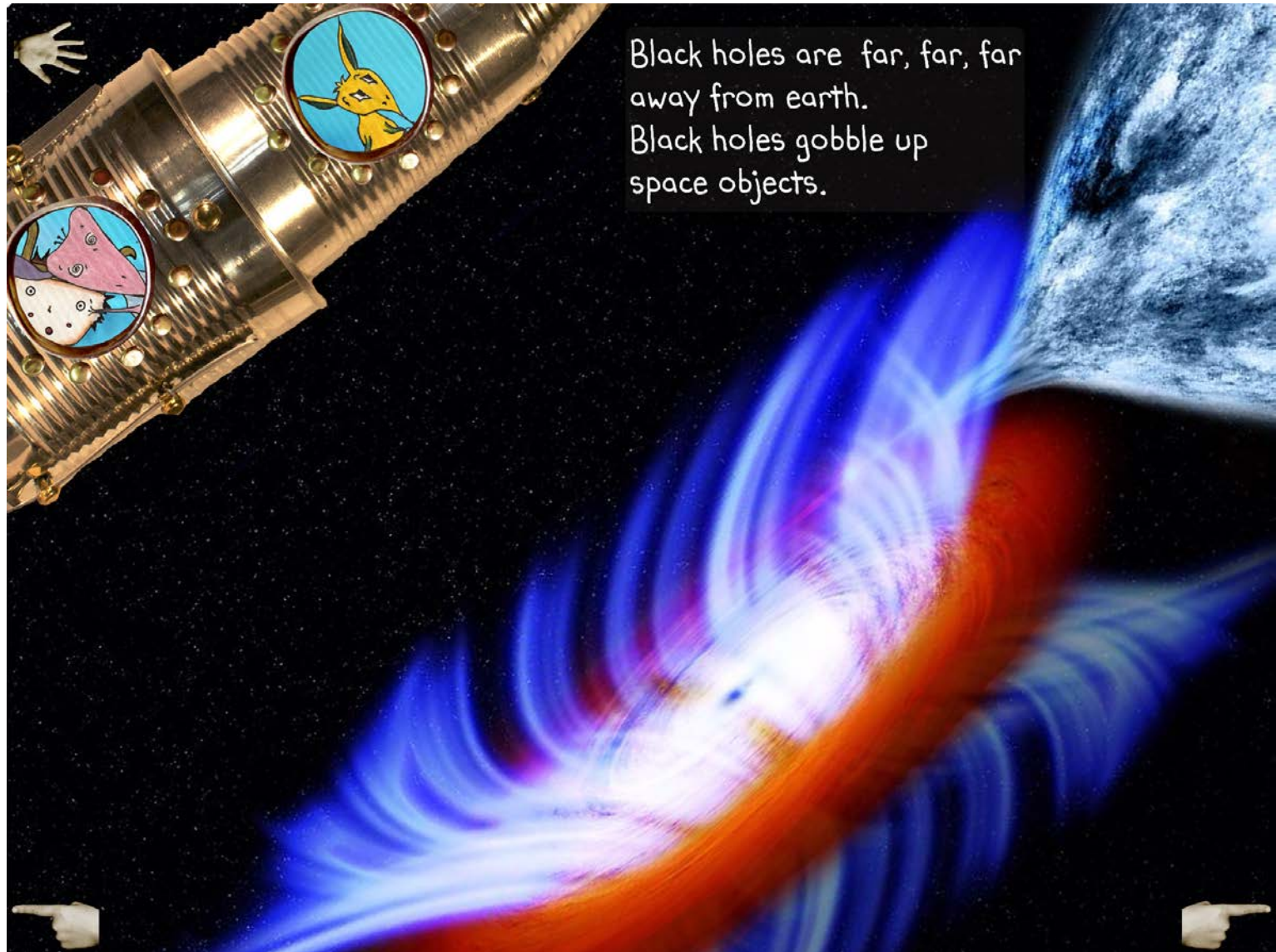
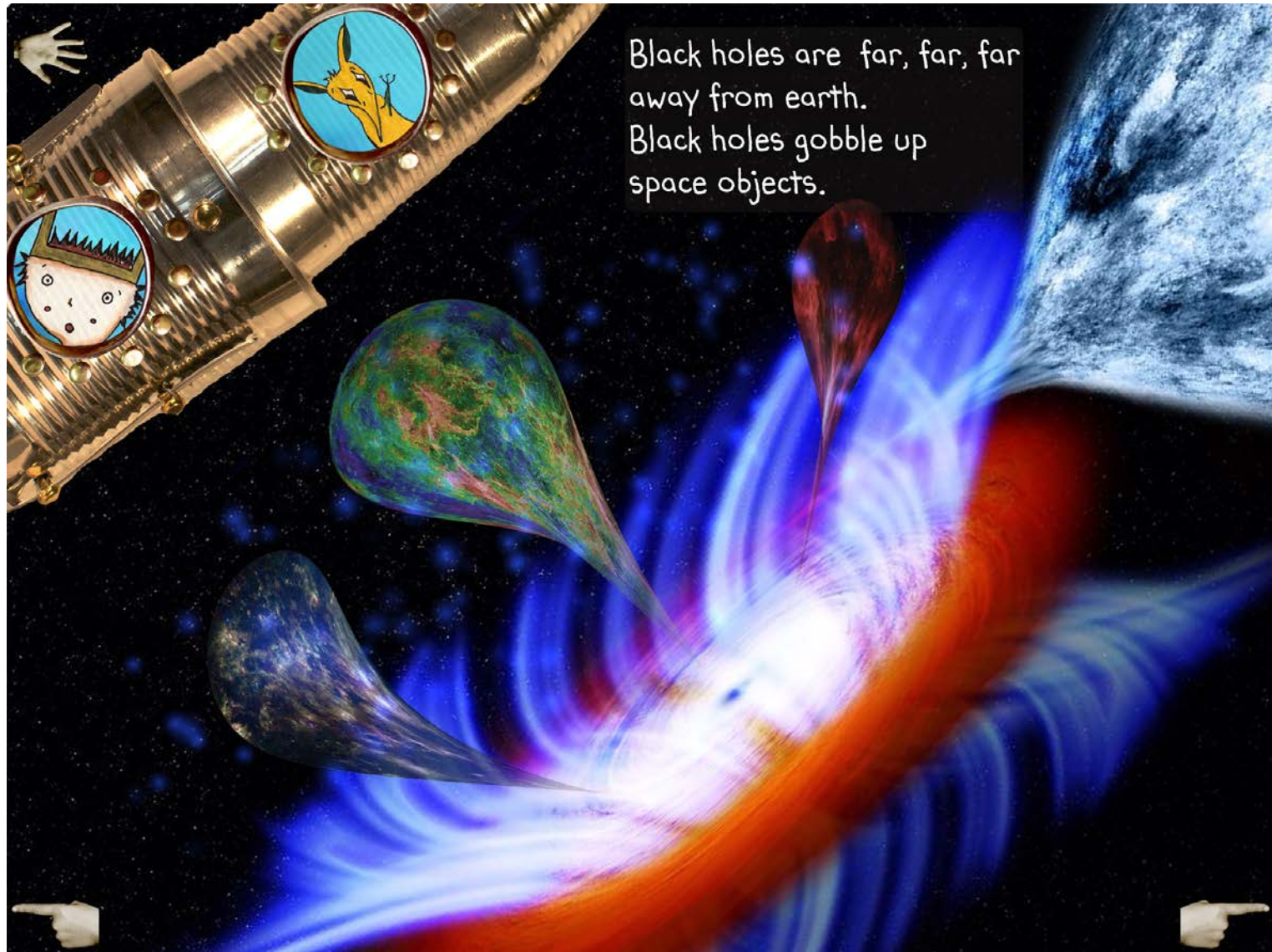


Figure 21
Scene 9: *How Far is Up?*
Users can trace their finger on
the screen in order to draw
particle images.



Black holes are far, far, far
away from earth.
Black holes gobble up
space objects.

In my case study analysis of *The Fantastic Flying Books of Mr. Morris Lessmore*, I demonstrated how the designers supply users with highly interactive features. When compared to the case study, the activities in *How Far is Up?* require a moderate level of user interaction. For example, users can tilt the device to navigate a rocket around a variety of scenes within this application (refer to Figure 19). My aim in designing the interactive features in *How Far is Up?* is to privilege narrative comprehension. This is in contrast to a design approach that may prioritise design competencies or hardware capabilities.

In designing *How Far is Up?* I aim to supply users with play activities that relate to and further inform the narrative. For example, as a result of moving the rocket object around the scene depicted in Figure 19, users can, as previously noted, be involved in proprioceptual experiences of distances and space. Users may only be engaged in a moderate level of action, yet they may still experience pleasurable feelings associated with taking *effective* action within this narrative-based environment. As a consequence, they may experience agency. Murray reminds us, after all, that agency is the result of taking meaningful action; it is not an experience that necessarily relates to the presence of highly interactive content (2012, pp. 12–13).

In my survey of book applications and in the case study analysis, I assessed the design of some applications' supplementary materials, noting potential ethical implications associated with supplying certain Internet links within works for young children. When designing the supplementary materials for *How Far is Up?* I have been mindful of my audience, and the relevant regulatory requirements. For example, I do not collect user data and I have not included links to social networking platforms or third party websites.⁴⁷ There are, however, Internet links within the *How Far is Up?* supplementary materials. The *How Far is Up?* teacher's notes and short film are housed on webpages that I have designed and customised. I maintain and have control over these webpages, so I can guarantee that these materials are suitable for four- and five-year-old children. When designing these webpages, I have minimised further links that may connect users to third party websites, in an attempt to limit children's unfettered access to the Internet.⁴⁸

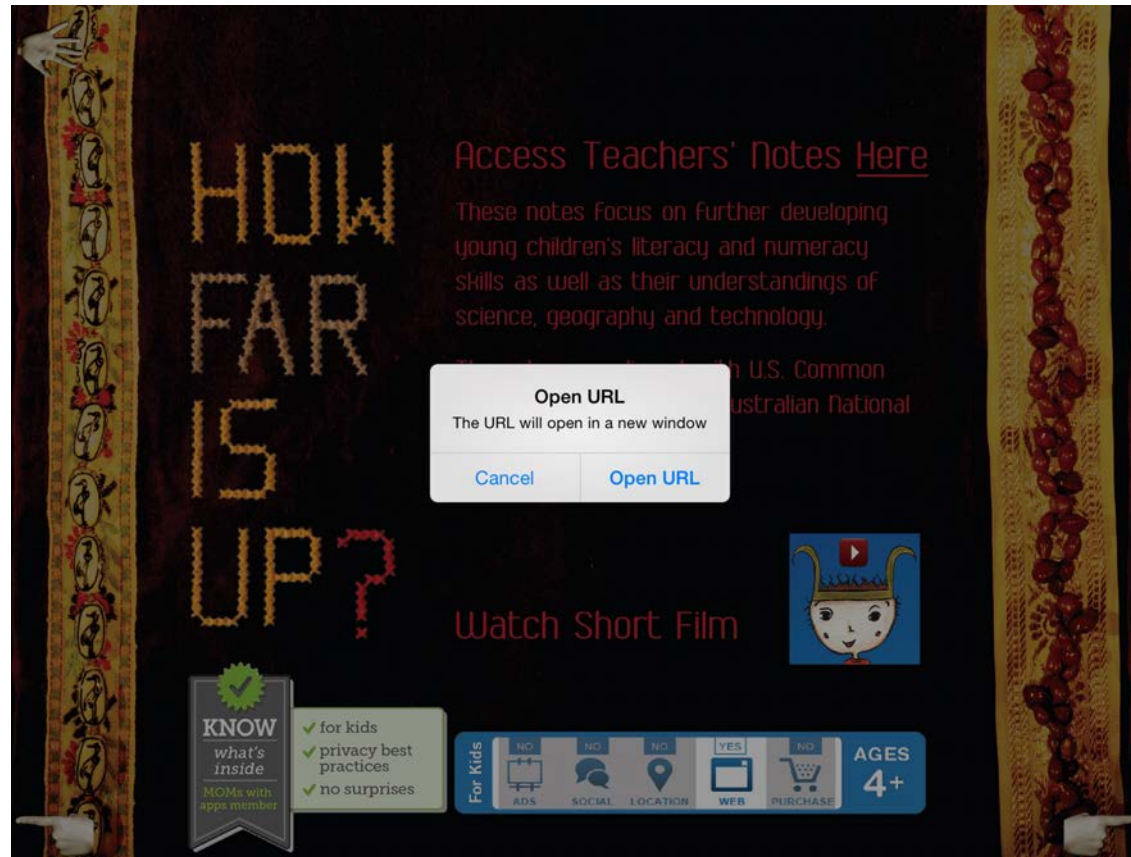
Users cannot directly access the teacher's notes and short film from the *How Far is Up?* homepage. They must navigate to the application's map (Figure 25), then to the supplementary materials page, and then to the materials themselves. I have reduced access to these materials with the intention of limiting occurrences whereby young users unintentionally navigate to these remotely housed features. These supplementary features are appropriate for young children, yet they are primarily designed to support adults who wish to use this application as an educational tool, within kindergarten, school or domestic settings.

⁴⁷ As an application developer, I have accreditation with two foundational quality control industry bodies within the United States: *KidSafe* and *Know What's Inside*. *How Far is Up?* has been approved by both of these organisations. This application has been approved because: it clearly aligns with the Children's Online Privacy and Protection Act; it clearly informs literate users and purchasers that there are Internet links within the application; and the content is appropriate for the target audience.

⁴⁸ I could have embedded the *How Far is Up?* short film and teacher's notes within the application. I elected not to use this design approach, as I was cognisant of minimising the overall file size of the application in order for it to be easy to download and to store on mobile devices.

When users attempt to access the *How Far is Up?* teacher's notes and short film, a window appears, as depicted in Figure 22. This window alerts literate users that they are about to navigate outside the application environment. Similar to what was revealed in the case study analysis, this design technique serves as a gating system that may restrict children's access to these external pages. It does not entirely prohibit access, but may operate as a barrier.

Figure 22
Supplementary Materials:
How Far is Up?
A window appears prior to
users connecting to external
webpages.



The case study analysis demonstrates that the designers do not take productive measures in order to foster shared book reading. The designers do not overtly encourage adults and children to experience the application content together. Some designers actively develop digital alternatives to shared book reading. For example, book applications can contain a “digital tutor” (Smeets and Bus 2013). These virtual assistants ask questions of children, and prompt users to engage and interact with the content in a book application (p. 183). Findings on the effects of this design technique demonstrate that “the best dialogic reading occurs [when] the parents read the book together with their child” using the digital tutor to “promote more discussion around the book contents” (Mori et al. 2011, p. 826). It appears that digital tutors can be useful support tools, yet adults still have a vital role to play in reading together with young children.

Löwgren acknowledges that non-digital interaction is an area that is only just gaining interest in the field of interaction design (2014). I have investigated this area of design within this project.⁴⁹ In shaping *How Far is Up?* I intend to support interaction between adults and children. As Smeets and Bus state, shared reading is “fun and supportive of emotional bonding with a child”; consequently, “it is important that parents and preschool teachers continue reading to younger age groups” (2013, p. 185).

As previously noted, the written text in *How Far is Up?* is not ‘read’ by the narrator. For example, the written text in Figure 23 states: “Over time, galaxies move. These two galaxies could be dancing”. The accompanying narration states: “Past outer galaxies”. I have presented different narrative information within these two structures of the application. One effect of this design technique is that in order to comprehend the textual aspect of the narrative, a pre-literate child will need someone to read the written words aloud. In designing *How Far is Up?* I encourage adults and children to come together, and explore the content contained within this application.

⁴⁹ Growing interest in the ways that designers can foster social interaction over a shared mobile device is evident in *How Far is Up?* being selected for inclusion in *Interactivity* at CHI 2014. The CHI conference is highly regarded within industry and academic circles that address human-computer interaction. CHI is a premier international conference on “human factors in computing systems” (ACM SIGCHI 2014). I was invited to exhibit *How Far is Up?* at this event alongside sixty other innovative interactive technologies from around the world. My work was selected for this tightly curated CHI event on the basis of how the design fosters social, intergenerational interaction over a shared mobile device (Sargeant and Mueller 2014). The selection process for this exhibit involves rigorous peer review.

Figure 23
Scene 8: *How Far is Up?*
The text in this excerpt differs
to the audio narration.



It is expected that many pre-literate children will be able to understand and enjoy the *How Far is Up?* story even if the written text is not read aloud; indeed the evaluation study, included in appendix A, shows that they can. Yet through adult participation, children may learn more about the narrative content; anecdotal evidence, provided in appendix A, suggests that this may be the case. This design tactic is intended to provide positive independent and shared reading experiences. This design method may have the effect of strengthening emotional bonds between adults and children; it may also help to further educate children by encouraging shared reading that may deepen a child's understandings of narrative content.

Smeets and Bus describe the difficulties of designing for adult participation in children's books. They state that when reading to young children, adults "might not know which words to comment on or which events to discuss" (2013, p. 185). Yet adults are, however, able to adapt their readings of picture book content according to a child's needs (2014, p. 185). It appears that if a child does not understand some aspect of a picture book, then adults are able to identify this and may provide clarity (p. 185). In recognition of these findings, I have provided narrative information in *How Far is Up?* that may challenge young minds. This design method is intended to involve adults in helping children decipher narrative meanings. For example, as depicted in Figure 24, this application contains a scene that features an aerial photograph of an Earth-bound landmass superimposed over an image of the Moon. This scene is designed to encourage adult users to help children compare distances that occur on Earth with the size of the Moon. My aim in designing this material is to provide an invitation for adults to engage in conversation with children over this aspect of the book's content. It is a trigger that may help adults identify events within the story that they can discuss with children during shared reading sessions.

Figure 24
Scene 6: *How Far is Up?*
I superimpose aerial images of Earth-bound landmasses over an image of the Moon. In doing this, I encourage users to compare distances found on Earth with the size of a space object. Through discussing this idea with an adult, child audiences may develop deeper understandings of these types of comparative concepts.



5.4.1 Summary: Being Involved

In summary, this analysis demonstrates how I have used interactive features within *How Far is Up?* as a means of directing users' attention towards narrative content. My design may not be as highly interactive as that seen in the case study, yet it may still provide users with an experience of agency. As Murray states, agency does not relate to levels of interactivity, but to taking meaningful action in a digital environment (2012, pp. 100–03).

This analysis also demonstrates how the design of *How Far is Up?* may include what Löwgren calls ethical and social aspects of interaction design (2014). Where Murray shies away from addressing “social participation” (2012, p. 433), I intend to find connections between digital media and wider social concerns.⁵⁰ For example, I have consciously shaped the contents of the *How Far is Up?* supplementary materials to ensure that these aspects of the application are appropriate for my target audience. Further to this, I aim to create an artefact that fosters adult participation. *How Far is Up?* is created for independent and shared reading. By supplying separate information in the text and audio narration, and by providing material that may challenge young minds, I invite adults to join with children in reading and deciphering meanings from the content provided. This design tactic is directed towards the larger strategy of engaging users in social interaction over a shared mobile device.

I will now apply the case study findings, relating to the spatial properties of the digital medium, to an analysis of *How Far is Up?* This is with a view to assessing the materials that I have used and the creative arts processes involved in shaping this application.

5.5 DESIGNING VIRTUAL ENVIRONMENTS: THE SPATIAL PROPERTIES OF *HOW FAR IS UP?*

We saw in the case study analysis that the designers of *The Fantastic Flying Books of Mr. Morris Lessmore* provide users with a homepage from which they can access supplementary materials. The designers also provide a table of contents from which users can access different story locations. I have taken a different design approach when communicating the spatial organisation of *How Far is Up?* My approach draws on conventions used in site map design.⁵¹ I have provided users with a map (depicted in Figure 25) that provides an overview of and access to specific points in the application's story. This map also provides access to the supplementary materials (via the circular tabs labelled “?”, “C” and “I”). This map provides a global perspective of the application's

⁵⁰ It should be noted that my design processes do not incorporate Druin's notion of participatory design. I do not include children in the design process.

⁵¹ According to graphic designer David Whitbread, a site map is a hierarchical diagram that identifies connections between the content contained in a website (2009, p. 128).

content and allows access to this content. This map may assist users in comprehending the spatial layout of this application. It may also assist them to successfully navigate and distinguish between the different places contained in this work.

Figure 25
Application Map:
How Far is Up?
This pictorial map visually tracks the locations featured in the story. It also provides access to the supplementary materials.



The case study analysis demonstrates how the designers use text, visuals and audio as a means of constructing what Murray may call distinct places. I have used these same media components within *How Far is Up?* in order to highlight distinct places within the overall digital space. For example, the scene depicted in Figures 26 and 27 is shaped through the use of text, imagery and audio. These media components describe a scene that shows a wide sky and diminutive-looking characters situated on (or around) a distant mountaintop. This scene is distinct from the previous scene, which features a middle-distance perspective of the mountain (Figure 29). The scene shown in Figures 26 and 27 is also different to the following story location, which features a fictionalised image of outer space (Figure 24). The location shown in Figures 26 and 27 is a distinct place within this fiction.

I have used counterpointed techniques in order to shape the relationship between the media components in Figures 26 and 27. According to Nikolajeva and Scott, counterpointed content can engage audiences' imaginations (2006, pp. 17–24). Audiences may employ their imaginations in order to elicit narrative meaning from counterpointed materials (p. 24). For example, the text that appears in Figure 26 provides facts about space. The visuals in this scene show the transition between day and night. The accompanying audio narration states: “Up. Past clouds”; this narration may encourage users to imagine what is beyond the Earth’s atmosphere. These central components describe different parts of the *How Far is Up?* story. These components are complementary, yet counterpointed. In order to form narrative meanings from these materials, users may need to engage their imaginations.

The images depicted in Figures 26 and 27 reflect a crucial moment in the *How Far is Up?* story. This scene operates as the border between the characters’ capers on Earth and their space explorations. It also contains a key transition between day and night. As night falls in *How Far is Up?* the narrative action becomes less realistic. Perhaps the characters are engaging in imaginative play, re-enacting space travel. These nocturnal locations may also represent dreamscapes. Nikolajeva and Scott state that picture book stories may present a “desire”; characters, or the audience, may “wish” that the events had taken place (2006, p. 173). As Smeets and Bus acknowledge, illustrations in “picture storybooks are works of art that must be interpreted” (2013, p. 186). In this instance, the characters may be experiencing desires or dreams involving intergalactic travel. Users may engage their imaginations in order to decipher their own meanings from the narrative messages conveyed in this scene.

The case study analysis also demonstrates how the designers have provided interactive activities that may lead to memorable user experiences. Similarly, in making *How Far is Up?* I have shaped written text, imagery, audio and interactive features with a view to providing pleasurable, memorable user experiences. This idea can be understood through further analysis of Figures 26 and 27. In this scene, I have provided users with a narrative-related interactive activity. Users can tilt their mobile device and move a rocket object around this virtual environment. In making this scene, I have used a range of sensory materials with the aim of richly describing a responsive narrative environment. As a result, users may become imaginatively and proprioceptively engaged or immersed in this scene. This may become a memorable immersive experience for users.

My approach to designing what Murray calls a memorable user experience involves a counterpointed triad of interactive content. As Nodelman reminds us, picture book storytelling involves shaping an “imaginative experience” for the reader (1988, p. 283). In this instance, I have deployed written text, imagery, audio and interactive features with the goal of imaginatively engaging users in this fiction.

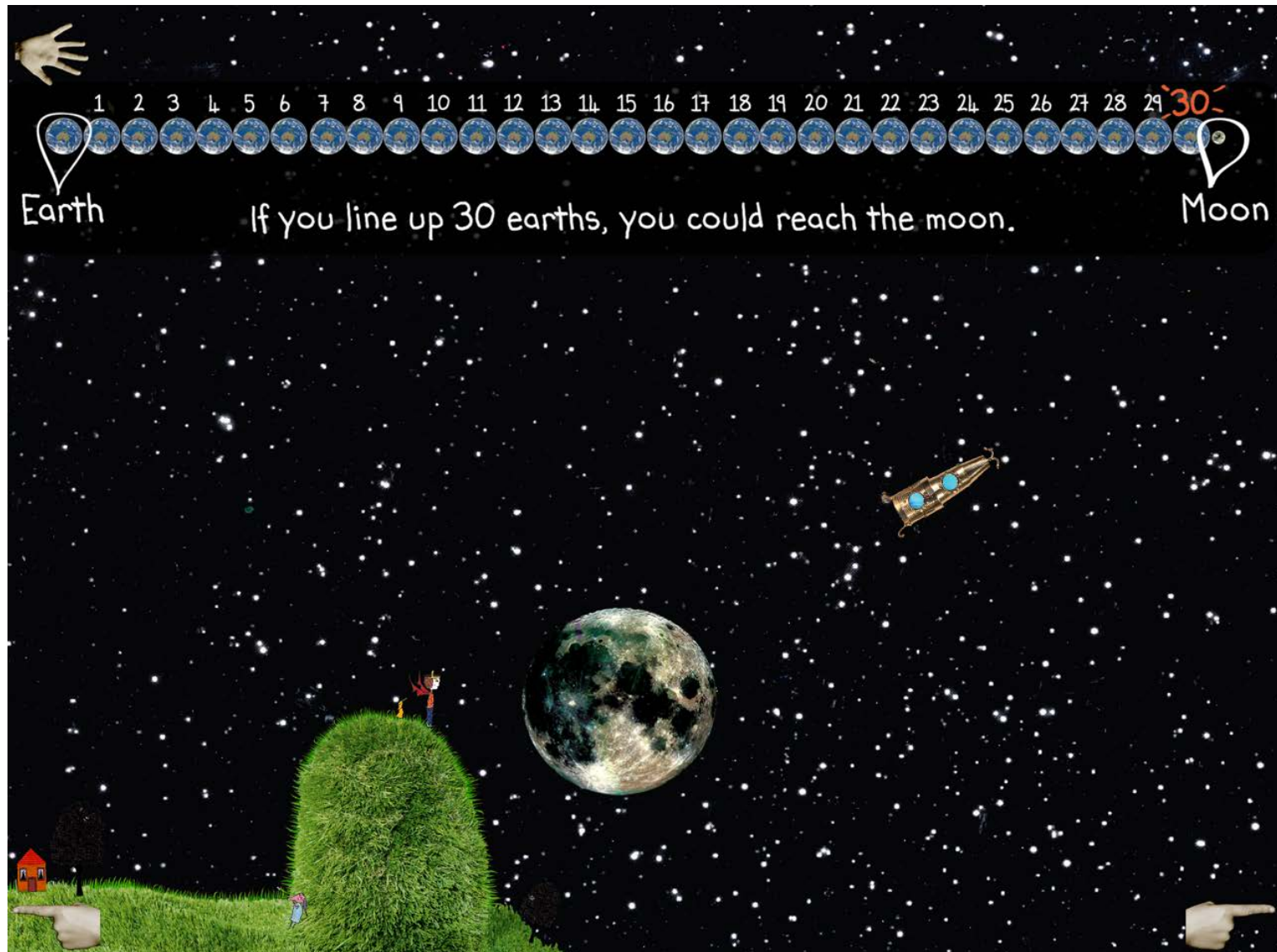
Figure 26

Scene 5: *How Far is Up?*

This excerpt depicts the transition from day to night. I invite users to imaginatively transfer themselves into this fictional place.



Figure 27
Scene 5: *How Far is Up?*
Users may engage their imaginations in order to decipher meanings from the counterpointed content in this scene.



My assessment of *The Fantastic Flying Books of Mr. Morris Lessmore* did not involve in-depth analysis of the range of practices that designers can undertake when making a fictional space. Jung and Stolterman acknowledge the important role of materials and making processes within interaction design (2012). Materials and methods of working can, according to Jung and Stolterman, be grounded in traditional techniques and cultural practices (2012). I will now analyse the materials and methods of practice that I have used when forming the text, visuals and audio for *How Far is Up?* In this discussion, I note the aesthetic and material qualities of the central components of the design.

5.5.1 The Written Text

The process of shaping the written text for *How Far is Up?* has involved composing three distinct textual threads. These threads are made up of: written dialogue, factual text and spoken narration (refer to Figure 28).⁵²

Figure 28
The *How Far is Up?*
written and verbal texts.

Scene	Written Dialogue	Factual Text	Spoken Narration
Opening	Rusty: Hi, I'm Rusty. Ting: I'm Ting. Buster: And I'm Buster		How far is up? [Curtain opens and RBT enter]
1	Ting: Will we ever reach the sun, or is it too far up?		UP. The tip of my fingers [RBT reach towards the sky]
2	Ting: Come on Buster. Buster: Ah...um...		UP. The top of the cupboard [RBT climb up cupboard]
3	Rusty: Yippee... Buster: Come down. You are too far up.		UP. The tallest tree branch [RBT climb tree]
4	Ting: The top of the cupboard. The tallest tree branch. The peak of a mountain. What next?	It takes one year for earth to travel around the sun.	UP. The peak of a mountain [The scene transforms from day to night]
5		If you line up 30 earths you could reach the moon.	UP. As far away as clouds. [Big night sky. RBT are small and distant]
6		The moon is almost as wide as Australia. The moon is almost as wide as America.	Past the moon [RBT in space ship travelling around the moon]
7		The Milky Way is made up of about 300 billion stars. Meteors can be seen at night. They are sometimes called shooting stars. Comets are made from ice, rock and dust. They are sometimes called dirty snowballs.	Past stars, comets, meteors [RBT travelling in space]
8		Over time, galaxies move. These two galaxies could be dancing.	And outer galaxies. [Video of galaxies shifting]
9		Black holes are far, far, far away from earth. Black holes gobble up space objects.	UP. Beyond black holes filled with wonders. [Animation of black holes]
10	Rusty: Oh Buster! Where are we?		UP. Further than our universe. [RBT in panic]
11			[RBT floating in space]
12	Buster: Don't worry, I know the way home.		Sometimes up is far, far, far above me. [Buster flies Rusty & Ting home]
13			And sometimes I can almost touch it. [Curtain closes on RBT]

⁵² I compiled the *How Far is Up?* texts in a spreadsheet with the aim of organising each aspect of the textual design. The spreadsheet provided a central file from which I could track the development of the written and aural texts.

According to Nikolajeva and Scott, written text can describe a fictional space (2006, p. 61). I use the three textual threads (shown in Figure 28) to describe different aspects of the *How Far is Up?* story. This idea may be further understood through analysis of the content in Figure 29. The written dialogue in this instance operates as an inner monologue; an expression of Ting's thoughts. Ting states: "The top of the cupboard. The tallest tree branch. The peak of a mountain. What next?" Ting is recounting the action that has occurred in the story and is inquiring about what is to come. This text alludes to Ting's curiosity. The dialogue and inner monologues contained in this application operate as character descriptors. The factual text, which appears underneath the image of the Sun in Figure 29, contains astronomical facts. This text states: "It takes one year for earth to travel around the sun". Finally, the spoken narration that accompanies this excerpt states: "The peak of a mountain". This narration describes the characters' progression through space, noting the main features that they observe. These three texts are descriptive, yet they each contain different story-related information. In designing the texts in this manner, I have incorporated a high level of narrative detail in order to further describe this fictional space.

Figure 29
Scene 4: *How Far is Up?*
There are three narrative threads within the written and aural texts in this application. There is written dialogue, factual text and spoken narration.



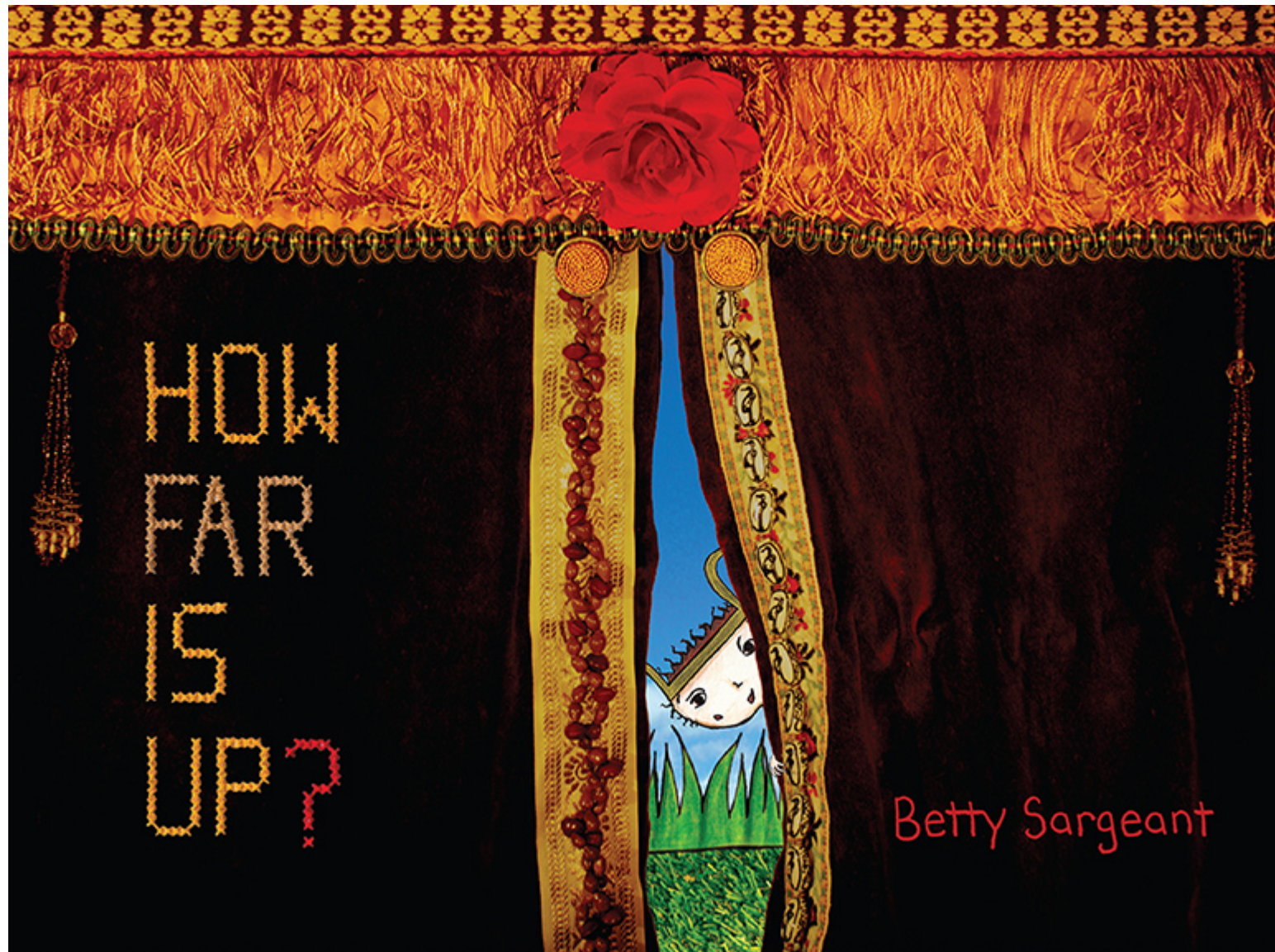
I have presented the written words in *How Far is Up?* through deploying two different visual methods. Firstly, I created the visuals for the book title through the process of hand embroidery (refer to Figure 30). I then scanned this embroidery and digitally removed the fabric background so that only the cross-stitched letters remain (refer to Figure 31). I have deployed this crafting method in order to create a unique typeface for the title page, one that is derived from traditional needlepoint techniques.⁵³

Figure 30
How Far is Up?
Title Typography.
The original hand
embroidered title lettering.



⁵³ It should be noted that *How Far is Up?* is not a nominal title; it operates as a guide that suggests to users what the story will address. Nikolajeva and Scott state that, “since the amount of verbal text in picturebooks is limited, the title itself can sometimes constitute a considerable percentage of the book’s verbal message” (2006, p. 241). Titles can provide readers with an “interpretative strategy” (p. 243). The *How Far is Up?* title may inform users that this book covers ideas relating to ‘far’ and ‘up’.

Figure 31
Homepage: *How Far is Up?*
The embroidered title lettering
was digitally layered within
the final application.



Secondly, I created a handwritten typeface for *How Far is Up?* I constructed this typeface from my own handwriting. I then worked within software to convert my handwriting into a usable font. In making both the embroidered title and this handwritten typeface, I am not aiming for precision lettering. I am intentionally incorporating a hand-crafted quality, one that emphasises the traditional art and design practices that can be deployed in application design. These sensory qualities of my work may provide a tactile lure into the screen environment. Through these material elements, I draw a connection between the digital environment and physical actions and experiences, linking this artefact to wider creative and communications practices.

5.5.2 The Visual Design

In describing the ways in which words and imagery contribute to the formation of narrative space, Nikolajeva and Scott state that, while “words can only *describe* space, pictures can actually *show* it” (2006, p. 61, emphasis in original). They observe that an illustrator can “in an instant communicate information about appearance” (p. 83). *How Far is Up?* contains visuals that combine illustration, original photography, three-dimensional set designs and NASA imagery. This diverse range of imagery is constructed from a variety of materials and making processes.

According to Löwgren and Stolterman, the process of “composing” the appearance of a system or artefact is a central aspect of interaction design (2004, pp. 53–54). Furthermore, Jung and Stolterman note that selecting materials is a “part of the design problem” and selection is based on “understanding [the] characteristics of a variety of materials” (2012, p. 647). In keeping with these ideas, the process of making the character illustrations for *How Far is Up?* has involved numerous exploratory tests (refer to Figures 32, 33, 34 and 35).⁵⁴ It has involved experimenting with acrylic paints, inks and pencils. I have used coloured pencil and ink on paper⁵⁵ to form the final character designs. These materials have allowed me to create naïve character depictions. My intention is to contrast naïve designs, and the simple materials used in their construction, with the realistic representational qualities of the digital NASA space photography.

⁵⁴ In 2012, I was awarded an Eleanor Dark Second Book Fellowship. This residential award was provided to support my process of illustrating the characters for this application. Consequently, the illustration work for *How Far is Up?* was undertaken during this fellowship at Varuna Writer’s House, Blackheath, Australia.

⁵⁵ I have used 270 GSM (grams per square metre) medium texture watercolour paper.

Figure 32
An early character
sketch of Rusty.
Throughout the making
process, I have experimented
with a variety of illustration
methods and materials.



Figure 33
Early turnaround of Rusty.



Figure 34
Early turnaround of Ting.

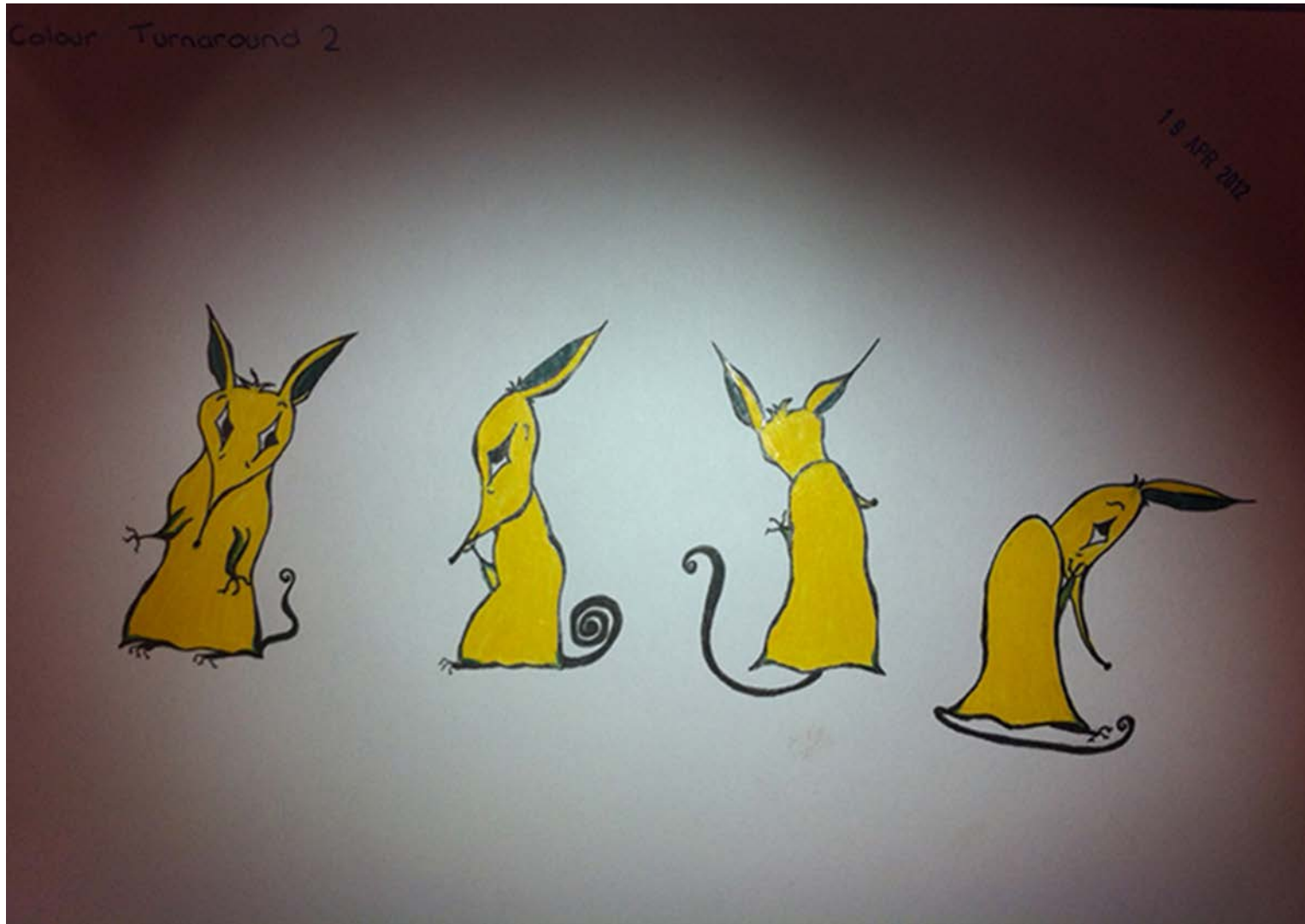


Figure 35
Illustrating *How Far is Up?*
during a 2012 fellowship at
Varuna Writer's House,
Blackheath, Australia.



In the process of creating the character designs, I scanned each illustration. The final character images have been formed using digital processes, such as cropping and removal of background information. The process of forming the characters has involved both digital and non-digital design practices.

Jenkins states that characters can operate as “our guides” through “richly developed worlds” (2004, p. 122). For example, *How Far is Up?* contains three characters that operate as narrative guides.⁵⁶ Buster and Ting are anthropomorphised. In its most raw form, anthropomorphism may be viewed as the presentation of “humanised animals” (Nodelman 1988, p. 35).⁵⁷ I have created anthropomorphic characters in order to reinforce the fictive aspects of this work. Through using this approach to character formation, I invite users to engage in a world where a child’s pet or imaginary animal friend may speak and become an intergalactic travelling companion. I have used non-realistic character representations as a means of engaging users’ imaginations in the story content.⁵⁸

Similar to what was revealed in the case study analysis, making the visual aspect of this application has also involved set construction, as depicted in Figures 36 and 37. The materials used in these model sets include cardboard, polystyrene, synthetic turf, pins and glue. Figure 38 shows how I photographed the settings in order to incorporate them into the digital layout. Figures 39, 40 and 41 display the making processes involved in creating the house and rocket objects that feature in *How Far is Up?* Figure 42 shows my studio, the physical location in which these items have been made.

⁵⁶ Nikolajeva and Scott state that “the ‘I’ in the text may relate to many different characters” (2006, pp. 124–29). They explain this by saying that characters in the visual narrative may represent aspects of the central child protagonist’s “subconscious” (pp. 126–27). In the context of *How Far is Up?* Buster and Ting may be viewed as aspects of Rusty’s subconscious.

⁵⁷ The concept of anthropomorphism has a long history in relation to children’s literature. The concept has strong socio-political traces and is often viewed from post-colonial perspectives and via notions of hybridity (Rudd 2009; Sargeant 2012).

⁵⁸ According to Nikolajeva and Scott, animal representations are “a frequent and significant characteristic of children’s literature” (2006, p. 92). In creating these types of characters, illustrators usually transform animals “into anthropomorphic beings with human attributes, including speech, human motivation, and often clothes and social status” (p. 92). For example, Buster and Ting in *How Far is Up?* communicate using the English language. By giving them dialogue and human motivations, I have anthropomorphised these characters. Similarly, in providing Rusty with costume-style wings, I have drawn connections between humans and animals, suggesting a veiled notion of hybridity (Latour 1993).

Figure 36
The *How Far is Up?* set
construction process.
Many of the settings were
constructed as three-
dimensional sculptural
objects.



Figure 37
The *How Far is Up?* set
construction process.



Figure 38
Photographing the
How Far is Up? sets.
I photographed each of the
sculptural models so that they
could be incorporated into the
digital layouts that make up
the book's imagery.



Figure 39
Making the *How Far is Up?*
house.
This process involved
experimenting with a range of
mixed materials.

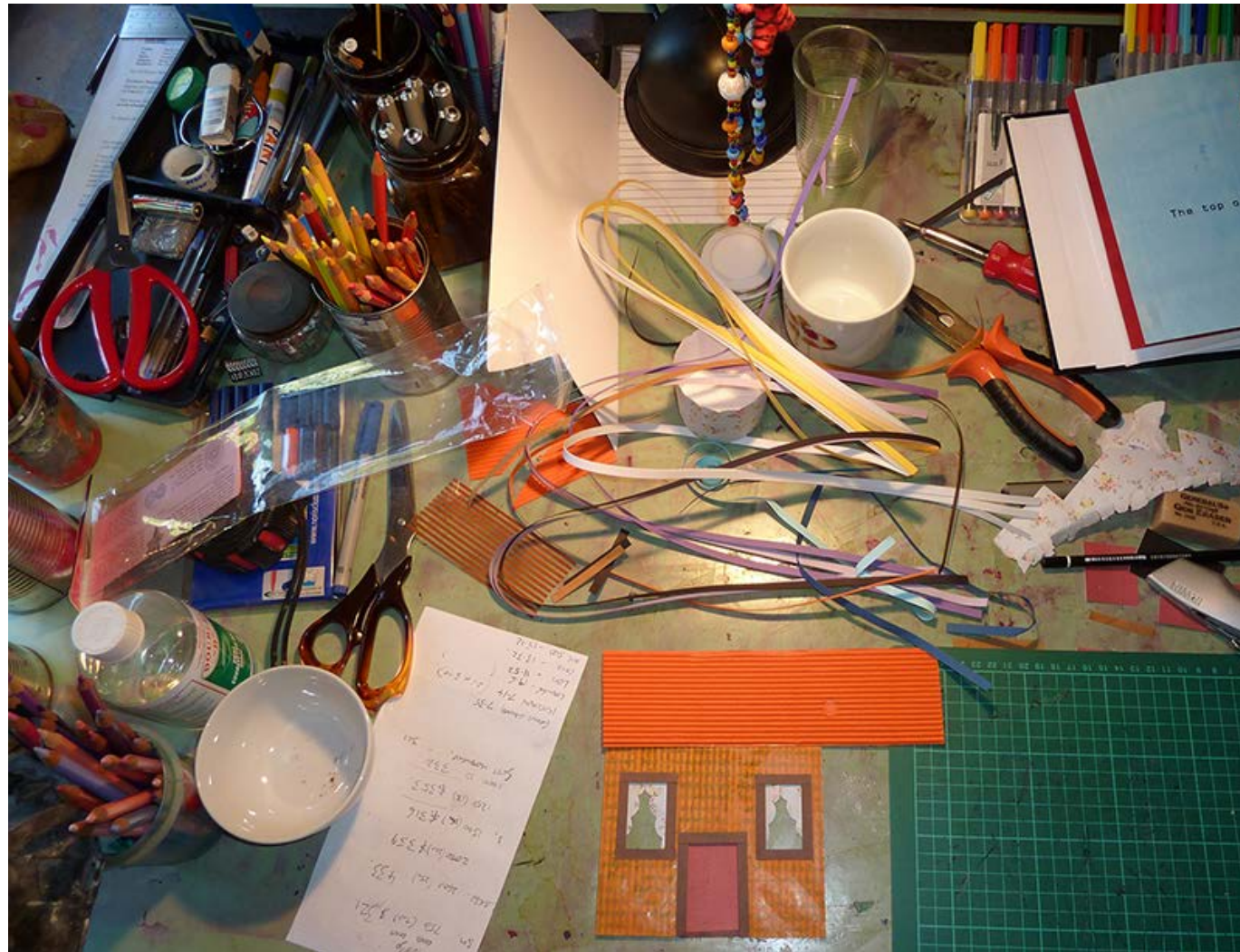


Figure 40
Making the
How Far is Up? rocket.



Figure 41
The final
How Far is Up? rocket.
This rocket is constructed
from tin cans, cutlery,
paperclips and a coat hook.



Figure 42
My studio during the
How Far is Up?
making process.



Nikolajeva and Scott note correlations between visual settings in picture books and theatre scenery (2006, p. 62). Similar comparisons may be made between the scenery in *How Far is Up?* and theatrical design methods. The sculptural sets in my application can be likened to scale-model theatre sets, as these items are similar in size, and they both serve the function of spatially representing (in reduced scale) an environment in which a story is carried out.

I have extended this theatrical connection by featuring a three-dimensional theatre curtain in this application (refer to Figures 43 and 44). I hand-stitched this theatre curtain. In doing this, I have used mixed media including fabric, braid and beads. Jung and Stolterman state that, “in traditional design disciplines, making has been a process of *crafting* aesthetic qualities of artefacts with particular materials” (p. 648, emphasis in original). In this instance, I have deployed a variety of materials in order to form a curtain. I have used this curtain as a means of visually suggesting how a historical, traditional crafting practice can be used in application design. I intentionally connect this digital environment with physical actions and activities, drawing on the processes and aesthetics involved in

theatre production. As a part of this design process, I photographed my hand-made theatrical curtain and have incorporated these images into the digital layout.

The *How Far is Up?* curtain not only elicits comparisons with theatre aesthetics; it also serves a theatrical function. This curtain functions as a framing device, one that draws on theatrical and picture book conventions. Nikolajeva and Scott state that in a picture book context:

Framing is an extremely powerful visual element of setting. Frames normally create a sense of detachment between the picture and the reader, while the absence of frames (that is, a picture that covers the whole area of a page or a doublespread) invites the reader into the picture

2006, p. 62.

I have used the *How Far is Up?* curtain as a means of framing, and concealing, the story's setting (refer to Figure 42). As the curtain opens, it reveals the world of the fiction. I have book-ended this idea by closing the curtain at the story's conclusion. Through using this visual motif, I gradually invite users to suspend their disbelief and imaginatively engage with the fiction; at the conclusion, I draw the curtains and restrict their view to this fictive realm.

Figure 43
The curtain
construction process.
I hand-stitched this curtain
using a range of mixed media.



Figure 44
Scene 13: *How Far is Up?*
The curtain operates as a frame that gradually reveals the story's setting. At the conclusion, I close the curtain on this fictive realm.



The final aspect of the application's visuals involves my use of NASA imagery (refer to appendix E for full credits and details). These images contrast with the hand-made aesthetic that is reflected in the typography, illustration and set design. I have consciously combined factual representations of space objects with idiosyncratically hand-crafted designs, in effect melding fact and fiction. I also contrast the precision of digital imagery with the human imperfections and unique qualities that can be associated with hand-made design techniques.

5.5.3 The Audio Design

During this design process, I have composed and performed acoustic piano music in order to further evoke a sense of space and place within this application (as depicted in Figure 45).⁵⁹ According to Smeets and Bus, music can have an emotional and evocative effect on children (2013, p. 180). The music that I have composed for this application is spacious, lyrical, non-percussive and loosely structured. My intention is to evoke feelings and associations related to traversing the exceptional distances that exist in our universe.

During the recording of the application's soundtrack, I opened the studio door at specific times so as to capture external natural bird sounds. Consequently, when users are wearing headphones, faint bird sounds may be heard on the audio track that accompanies Figure 46. These sound effects subtly reinforce narrative content related to flying.

When planning the music for this application, I consciously chose acoustic, as apposed to synthesised, instrumentation. The particular piano used is richer in tone when compared to its synthesised counterpart. The piano also has subtle tuning imperfections. I was not aiming for precision and perfection, but for a richly layered, unique audio aesthetic. These acoustic audio designs have been digitally incorporated into the application. I worked in a separate digital studio when designing these aspects of the work (refer to Figure 41). Similar to the written text and visuals, the audio design is comprised of both digital and non-digital practices and processes.

⁵⁹ When composing the musical score for *How Far is Up?* I wrote thirteen connected musical vignettes that range in length from seven seconds to six minutes. Most of the pieces are designed to be heard in a loop. This allows the musical accompaniment to continue to be heard regardless of the time that users spend on each page.

Figure 45
Composing the piano
soundtrack.



Figure 46
Scene 6: *How Far is Up?*
A lyrical, non-dynamic,
acoustic piano melody
accompanies this scene. The
audio recording also contains
subtle birdsong sound
effects. These audio features
may evoke associations with
flying.

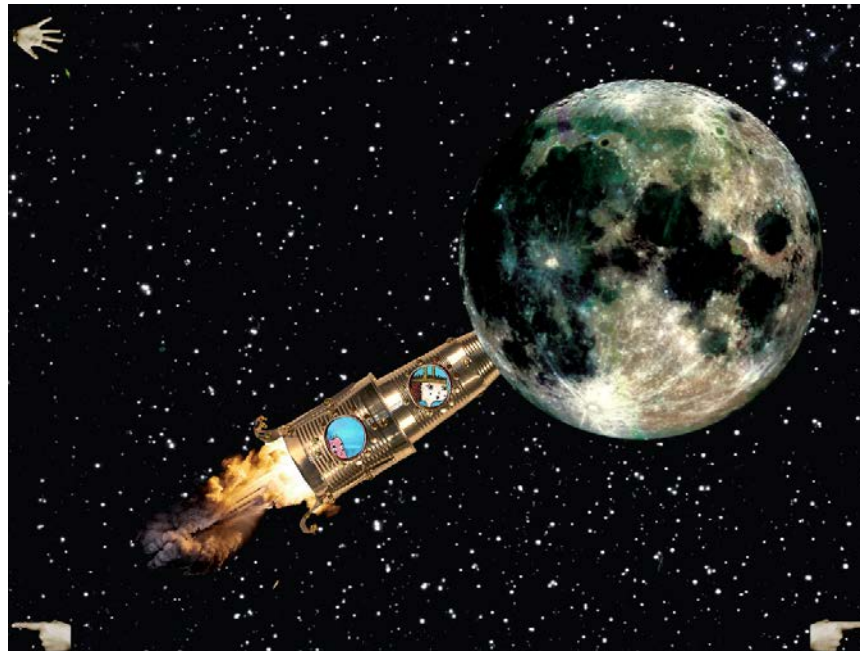


Figure 47
My digital workspace during
the *How Far is Up?* making
process.



5.5.4 Summary: Designing Virtual Environments

My analysis demonstrates how designers can shape what Murray calls distinct places and memorable user experiences. Through the use of written text, imagery, audio and interactive features, I provide users with a rich sensory environment, one that is (to an extent) responsive to user actions. In doing this, I have constructed a counterpointed triad of content that may imaginatively and proprioceptively engage users in playful narrative content.

My discussions on the written text, visuals and audio demonstrate the ways in which this work has been constructed from combinations of digital and non-digital practices, materials and processes. When making this artefact, I have fused traditional art and craft methods and computational design approaches. As Madej states, digital storytellers can draw on all previous storytelling methods (2003, p. 2). Through *How Far is Up?* I highlight a range of digital and non-digital practices, materials and processes that can be deployed when making a children's book application. In combining a variety of working methods and materials, I have presented the precision of computing alongside the idiosyncratic, human qualities that can be ascribed to hand-crafted design. In effect, I have borrowed from past traditions to help form a more richly detailed technological artefact, one that may be connected to lived experiences within the physical world.

In deploying this range of digital and non-digital practices and processes, I link this story-world to our physical environment. I use digital means to help form and depict hand-crafted design elements. I present activities that I have undertaken, such as handwriting and drawing. I visually reference experiences derived from the physical world, such as attending live theatre events. I invite a link between digital design and the natural world, by including bird sounds in the audio recordings. In doing this, I further extend the notion of the counterpointed triad technique, revealing the ways in which book application text, imagery and audio can support social interaction, as well as embodied experiences.

5.6 CHAPTER FIVE CONCLUSION: THE CREATIVE PROJECT

Through assessing the ways in which written text, imagery and audio can operate as a counterpointed triad, we can more deeply understand Murray's concept of the digital realm being a "compelling medium for narrative art" (1997, p. 84). By deploying triad techniques, designers may be able to unlock the potential for computing systems to operate as a highly efficient conduit for digital literature. This analysis demonstrates that through deploying these techniques, designers may imaginatively engage users in a sensory-rich narrative space.

In answering this third research question, I demonstrate how designers can draw on a range of media conventions. When making *How Far is Up?* I drew on conventions from picture book, game, theatre, graphic, website and interaction design, as well as protocols used in film-making. These conventions have social and cultural implications. This analysis highlights the potential for this medium to engage a dual audience of both adults and children in shared book reading. Furthermore, my use of hand-crafted techniques, techniques that have their roots in physical actions and experiences, further consolidate the link between this artefact and our physical world. Functional and aesthetic properties work together in order to: lure users into the work, and connect users to experiences that are derived from our physical world. I have drawn on a range of techniques in order to uncover the relationship between this artefact and historical shared reading activities, and arts, cultural and experiential practices.

Murray helps establish a clear understanding of the conventions used to form digital media and the functional properties of digital artefacts, yet she not contribute to investigations concerning social and embodied aspects of computing. Dourish helps establish a clear link between digital content and embodied experience; Munster connects digital art and media with social structures and embodied events; and Druin includes children in the process of making digital systems and artefacts, in doing this she creates a physical relationship between users and content. Extending from this body of knowledge, I have drawn on the rich tradition of picture book making, in order to form a link between functionality, materials, making processes, aesthetics and the social and physical experiences that children's storybook applications can give rise to.

I will now turn my attention to consolidating my findings in this next and final chapter.

6

Children's Book Application Design:

How Far is Up?

This project combines applied and theoretical knowledge derived from science and humanities traditions. My research examines ways in which interaction designers can shape sensory-rich children's book applications. I also analyse how book applications can operate as a means of communication, a form of expression, and a social and educational tool.

A substantial body of evidence suggests that there is a need for a more comprehensive set of principles aimed at guiding designers of book applications (Smeets and Bus 2013, 2014; Yokota and Teale 2014). In particular, there are concerns relating to the design of interactive activities. Evidence shows that these features can distract users from completing a story (Smeets and Bus 2013, 2014). My research findings also indicate further issues in this area. These issues concern: the relationship between written text, imagery and audio; a lack of book application content that is directed towards supporting a dual audience of adults and children; and the relationship between application aesthetics, materials and physical experiences.

My results demonstrate new insights that are focused towards three main areas of interaction design. Firstly, my findings demonstrate how designers can use a counterpointed triad of written text, imagery and audio, alongside the alluring qualities of animation and interactive features, in order to form a richly described narrative environment. I propose a design approach that may assist users to imaginatively engage in application content. Secondly, my results demonstrate ways in which designers can foster social interaction over a shared mobile device. This reveals social implications associated with designing sensory-rich, interactive works for children. Thirdly, within my results I propose a connection between picture books and book applications. This final finding tracks a relationship between materials, making practices, aesthetics and physical experiences.

6.1 ENCYCLOPAEDIC AND SPATIAL PROPERTIES: THE TRIAD TECHNIQUE AND IMAGINATIVE ENGAGEMENT

Murray acknowledges that the affordances of the digital medium do not operate in isolation from each other. In establishing her theories, Murray forms a cross-pollinating system. With this in mind, I couple together my findings that relate to what she may label as the encyclopaedic and spatial aspects of computing; these findings revolve around the counterpointed triad technique and imaginative engagement.

When making *How Far is Up?* I have fused a combination of counterpointed media. This literary method of working has allowed me to provide users with a wide range of narrative detail; as the written text, imagery and audio in this application each impart a different aspect of the overall story. I propose that this results in a counterpointed triad of media, that is, a counterbalanced combination of textual, visual and audio content that together constitute a richly described narrative environment.

When shaping the design I have deployed a moderate level of animation. In doing this, I have drawn on the picture book convention of implied movement, with the aim of suggesting action within a still image. This design technique may counter the ways in which young children can be visually “overloaded” by excessive amounts of animated movement (Smeets and Bus 2014, p. 180). I have applied discrete levels of animation in my application, alongside meaningful interactive features, using these alluring elements as a means to direct users’ attention towards important narrative detail.

Children’s literature research suggests that children remain “passive” when reading symmetrical picture book content; in contrast, they become imaginatively engaged when deciphering meanings from counterpointed media (Nikolajeva and Scott 2006, pp. 17–24). In making *How Far is Up?* I aim to create a playful design that can imaginatively engage users with sensory-rich story content.

6.2 PARTICIPATORY AND PROCEDURAL PROPERTIES: SOCIAL INTERACTION OVER A SHARED MOBILE DEVICE

Murray’s theories on interactivity involve both the participatory and procedural affordances of computing (2012, p, 432). In her studies, Murray does not analyse the relationship between interaction design and social interaction or what she calls “social participation” (2012, p. 433). According to Löwgren, qualities that are essentially “social or communal in their nature, such as ethical implications

and aspects of communication, are as yet somewhat underdeveloped in interaction design” (2014). My findings in this area relate to how we can program and design interactive artefacts in order to support social interaction over a shared mobile device.

Introducing “interactive computing to children’s lives at such young ages could lead to significant shifts in children’s interactions with the world around them” (Hourcade et al. 2015, p. 1915). There are of course positive and negative effects associated with children using computers, depending on how the technology is being used (p. 1917) and the content that is being consumed. A contemporary mobile device can be described as an “engaging device”; mobile hardware “requires deep human involvement with the object as a material thing” (Jung and Stolterman 2012, p. 649). These engaging devices can provide children with access to a wealth of valuable information and experiences (Yokata and Teale 2014). Yet we have come to view our relationship with digital devices as one that occurs in “solitude” (Munster 2011, p. 151). I have designed *How Far is Up?* so that children can engage with this application independently, while they are alone. In doing this I aim to create a design that maximises the engaging qualities of a mobile device (refer to Figure 48). Yet I also draw out the social potentials of this medium.

In my discussions on the participatory properties of the digital medium, I noted the body of literature that attests to the social and emotional bonds, as well as the educational outcomes, that are derived from adults and children engaging in shared book reading (Nikolajeva and Scott 2006; Smeets and Bus 2013, 2014; Yokata and Teale 2014). Social engagement is a crucial aspect of childhood development (Smeets and Bus 2013). This study demonstrates that a standard practice has been established within book application design. This standard practice involves designers creating a virtual narrator who reads to a child user. Adults are not required to read these works to children. In *How Far is Up?* however, I foster social interaction.

Due to my application of the counterpointed triad technique, I have included adult participation as a central component within this design. I have supplied users with separate information in the text and the audio narration, and provided material that may challenge young minds. Pre-literate children will need to engage in shared reading in order for them to understand the textural content. This design tactic aims to foster intergenerational social interaction over a shared mobile device (see Figure 49). Children can engage with this application while they are alone, yet through sharing the reading experience with an adult, children (and adults) may form deeper narrative understandings and closer social bonds. This disrupts our notion that human engagement with computers occurs in solitude.

How Far is Up?

Figure 48
A child reading in solitude.
The connection between a
child and a mobile device.



Figure 49
Shared reading of a
storybook application.
Social interaction over a
shared mobile device.



6.3 SPATIAL DESIGN: SOCIAL AND PHYSICAL ENGAGEMENT

The *How Far is Up?* application contains hand-made elements that reflect practices and processes derived from experiences and events that occur in the physical world. By including proprioception, aesthetic and sensory content, I draw a connection between this digital artefact and physical, embodied experiences. In programming this application's functionality, I provide users with proprioception experiences. I also used visual textures and audio designs in order to elicit wider social, cultural and physical associations. The material qualities in this artefact enliven a connection to our physical world. This expands upon the counterpointed triad technique. In making *How Far is Up?* I extended from theory relating to the picture book (Nikolajeva and Scott 2006). The *How Far is Up?* design reinforces a notion that book applications do not exist independently from the wider social and physical structures in which they made and may be experienced.

6.4 AREAS OF FUTURE RESEARCH

My research findings offer new knowledge relating to interaction design and children's applications. These results suggest further opportunities for a range of theorists and practitioners, including those in fields and disciplines such as literary studies, education, fine art, interaction design, game design and cognitive science. As a result of this study, I have identified four main directions for future research.

6.4.1 *The Triad Technique: Animated Typography and Audio Dialogue*

In my survey of book applications, I showed that some designers deploy animated typography as a way of drawing focus towards the written content in an application. Further studies could examine the range of techniques that designers use when shaping animated written text. These studies could broaden our understanding of how designers can deploy animation in order to capture users' attention and direct it towards textual aspects. When deployed alongside the triad technique, animated text may go some way towards combatting textual redundancy.

Future research could also address the ways in which book application narration can be informed by conventions used in film-making. Human-computer interaction theorists Marc Cavazza and Fred Charles state that dialogue "between feature characters [is] an essential component of traditional media, such as films" (2005). A standard in book application design is to present audio that

contains a single narrative perspective; this is evident in there being a single narrator within most book applications. Future research could investigate how audio *dialogue* can provide an alternative to the method of using a narrated monologue.

Through the use of animated typography and audio dialogue, designers can further counterpoint a story. These design approaches may reinforce a triad of counterpointed written text, imagery and audio.

6.4.2 Fostering Social and Physical Interaction over a Shared Mobile Device

Through this research project, I propose ways in which book application designers can foster social, intergenerational interaction over a shared mobile device. These ideas could be further evaluated, investigating: the ways in which adults discuss book application content with children, adults' experiences of shared readings of book applications, and comparisons between individual and shared readings of a variety of book application designs. These participant studies could help further consolidate knowledge of how mobile application designers can provide users with effective shared reading experiences.

Further research could also investigate ways of fostering physical interaction over a shared mobile device. Through the *How Far is Up?* research project I draw a connection between book applications and social and physical engagement. This is an area that can be further investigated. According to High Scope early childhood education theory, when four- and five-year-old children engage in physical movement, this can have positive developmental outcomes (Schweinhart 1993). Future studies could focus on how book application designers can trigger wider embodied experiences for users. These investigations could also analyse how groups of children can be encouraged, via book application content, to enact physical activities while sharing a tablet. This research could therefore lead to findings on how application designers can foster social and physical interaction over a shared mobile device.⁶⁰

6.4.3 Game Design Strategies in Book Applications

This research project demonstrates how book applications commonly contain play and puzzle activities, as opposed to structured games. Future research could investigate ways in which designers can use game design techniques within book applications, without diminishing game or narrative structures.

⁶⁰ An Australian government health foundation, VicHealth, predicts that by 2025 “over 75% of adults and one third of Australian kids will be overweight or obese and at severe risk of type 2 diabetes and cardiovascular disease” (VicHealth n.d.). Encouraging physical activity via an appealing means such as a mobile application may be of considerable value in such a health-challenged future environment.

Salen and Zimmerman state that by dividing games into different “levels”, designers not only provide a structure for the work, but also provide a motivational tool for players (2003, p. 261). Ideas relating to game levels could provide the basis for further research into the design of book applications. This future research could investigate ways in which designers can strengthen children’s engagement with narrative literature through creating book applications in which users can *earn* access to different levels of a story.

6.4.4 Ethics and Book Application Design

Mobile devices are commonly networked and this can lead to users forming and maintaining remote interactions. My survey of book applications demonstrates how designers can provide young children with links to social networking platforms (which are designed for older users) and email communications. In *How Far is Up?* I have taken active measures to circumscribe users’ access to the Internet. Legislation such as the Children’s Online Privacy Protection Act goes a considerable way towards providing designers with clear protocols. Yet it appears that some storybook application designers are still providing networked connections that are not tailored for young children.

Further research could compare ways in which developers incorporate digitally networked links into book applications. This research could investigate existing parental locking systems. Studies could be informed by legislative, industry and theoretical knowledge in order to gain better understandings of the ethical implications of networked digital design practices.

6.5 CHILDREN’S BOOK APPLICATIONS: FUNCTIONAL PROPERTIES AND AESTHETIC MATERIALITY

In making *How Far is Up?* I have engaged in, and analysed, a range of art, craft and digital practices. My applied methods have involved conventions derived from picture book, game, theatre, graphic, website and interaction design. I have also used techniques that originate from film-making practices. In addressing functional properties as well as aesthetically driven practices, an interaction designer can situate usable artefacts in a social and physical context, one that is connected to a history of making processes and experiential activities.

Murray provides a framework that allows for some aspects of book application design to be illuminated, particularly relating to combinations of content and functional design qualities. She also enlivens the notion of digital storytelling. Within this research project I applied further theory in order to understand the ways in which book applications can support social interaction and material,

How Far is Up?

physical experiences. Digital design is not simply shaped by computational bits (Munster 2011, p. 56). As Norman provocatively states, “attractive things work better” (2004). I uncover a notion of interaction design whereby digital designers fuse functionality with aesthetic representations of artistic and social practices; in order to make culturally valuable, usable digital artefacts. This research aims to establish an understanding of the design of book applications from technical, aesthetic and social perspectives.

Through analysing the functional and aesthetic values of book applications, I demonstrate new ways in which designers can remediate the picture book. My findings highlight: relationships between written text, imagery and audio; social issues associated with the design of children’s book applications; and connections between digital sensory experiences and physical, embodied practices and processes. My results show that this area of interaction design is rich with future possibilities.

References

- ACM SIGCHI 2014, CHI 2014, *One of a CHInd*, viewed 15 June 2014, <<http://chi2014.acm.org/>>.
- Apple Inc. 2015, *Compare iPad Models*, viewed 12 February 2015, <<https://apple.com/ipad/compare/>>.
- Asimov, I 1983, *The Measure of the Universe: Our Foremost Science Writer Looks at the World Large and Small*, Harper and Row, New York, NY.
- Barry, P 2002, *Beginning Theory: An introduction to Literary and Cultural Theory*, 2nd edn, Manchester University Press, Manchester.
- Barthes, R 1977, *Image, Music, Text*, trans. S Heath, Fontana Press, London.
- Birkerts, S 2006, *The Gutenberg Elegies: The Fate of Reading in an Electronic Age*, Macmillan, New York, NY.
- Bolter, JD and Grusin, R 2000, *Remediation: Understanding New Media*, MIT Press, Cambridge, MA.
- Bongers, B 2000, 'Interactivity in multimedia art', *Knowledge-Based Systems*, vol. 13, no. 7, Elsevier, pp. 479-485.
- Bongers, B and van de Veer, G 2007, 'HCI and design research education: A creative approach', *Creativity3: Experiencing to Educate and Design-Proceedings of HCI Educators 2007*, Designeed, Averio, Portugal, pp. 97-112.
- Bonsignore, E, Quinn, AJ, Druin, A and Bederson, B 2013, 'Sharing stories "in the Wild": A mobile storytelling case study using StoryKit', *Transactions on Computer-Human Interaction*, vol. 20, no. 3, article 18, ACM.
- Bradford, C 2012 'Narrative and computer games', in C Beavis, J O'Mara and L McNeice (eds), *Digital Games: Literacy in Action*, AATE Interface Series, Wakefield Press, South Australia, pp. 115-120.

References

- Candy, L 2006, *Practice Based Research: A Guide*, CSS Report, no. 1, Creative and Cognition Studios, Sydney, pp. 1-19.
- Carroll, JM 1990, 'Infinite detail and emulation in an ontologically minimized HCI', *Proceedings of the CHI 1990 Conference on Computer and Human Interaction*, Seattle, Washington, ACM, pp. 321-327.
- Carroll, JM 2014, 'Human Computer Interaction – Brief Intro', in M Soegaard and RF Dam (eds), *The Encyclopaedia of Human Computer Interaction*, 2nd edn, Interaction Design Foundation, Denmark.
- Castells, M 2010, *The Rise of Networked Society: With a New Preface*, 2nd edn, Wiley Online, DOI: 10.1002/9781444319514.
- Cavazza, M and Charles, F 2005, 'Dialogue generation in character-based interactive storytelling', in RM Young and J Laird (eds), *Proceedings of the First Intelligent and Interactive Digital Entertainment Conference*, American Association for Artificial Intelligence, Menlo Park, CA, pp. 21-26.
- Charity, MN n.d., *Cosmic View: The Universe in 40 Jumps by Kees Boeke*, viewed 20 January 2011, <<http://www.vendian.org/mncharity/cosmicview/>>.
- Coleridge, ST 1983, *The Collected Works of Samuel Taylor Coleridge: Biographia Literaria*, J Engell and WJ Bate (eds), Bollingen Series LXXV, Princeton University Press, Princeton, NJ.
- Collier, D 2012, *The Making of Morris Lessmore*, video recording, viewed 29 February 2014, <<https://www.youtube.com/watch?v=hRIK67AZSf4>>.
- Common Sense Media and Rideout, V 2013, *Zero to Eight: Children's Media use in America 2013*, Common Sense Media, San Francisco, CA.
- Cope, B 2001, 'New ways with words: Print and etext convergence', in B Cope and D Kalantzis (eds), *Print and Electronic Text Convergence*, C-2-C Project: Book 2.1, Common Ground Publishing, Altona, Vic.
- Crawford, C 2003, *The Art of Interactive Design: A Euphonious and Illuminating Guide to Building Successful Software*, No Starch Press, San Francisco, CA.
- Demibooks 2012, *Demibooks Composer User Guide: For Use within Composer Version 2.0*, Demibooks, Chicago, IL.
- Dethridge, L 2003, *Writing your Screenplay*, Allen and Unwin, Sydney.

References

- Donahoo, D 2011, 'The fantastic flying books of Mr. Morris Lessmore is a game-changing ebook app', *Wired*, 31 May, viewed 20 November 2012, <<http://archive.wired.com/geekdad/2011/05/lessmore/>>.
- Dourish, P 2001, *Where the Action is: The Foundations of Embodied Interaction*, MIT Press, Cambridge, MA.
- Druin, A 1999, 'Cooperative inquiry: Developing new technologies for children with children', *Proceedings from CHI 1999*, ACM, pp. 223-230.
- Druin, A 2002, 'The role of children in the design of new technology', *Behavior and Information Technology*, vol. 21, no. 1, Taylor and Francis, pp. 1-25.
- Eames, C and Eames, R 2010, *Powers of Ten (1977)*, video recording, viewed 20 January 2011, <<https://youtube.com/watch?v=0fKBhvDjuy0>>.
- Eisenstein, EL 2011, *Divine Art, Infernal Machine: The Reception of Printing in the West from First Impressions to the Sense of an Ending*, University of Pennsylvania Press, Philadelphia, PA.
- Facebook 2015, 'How do I report a child under the age of 13?', *Help Centre*, Facebook, viewed 03 February 2015, <<https://facebook.com/help/157793540954833>>.
- Federal Trade Commission n.d., *Children's Online Privacy and Protection Act (COPPA)*, viewed 20 October 2014, <<http://coppa.org>>.
- Frasca, G 2001, 'What is ludology? A provisory definition', *Ludology.org*, viewed 20 July 2013, <<http://ludology.org/2001/07/what-is-ludolog.html>>.
- Garnish, M 2011, *What is EPUB 3?*, O'Reilly Media, Sebastopol, CA.
- Gaver, W 1991, 'Technology affordances', *Proceedings of CHI 1991*, New Orleans, Louisiana, ACM, pp. 79-84.
- Genette, G 1985, *Narrative Discourse: An Essay in Method*, trans. JE Lewin, Cornell University Press, Ithaca, NY.
- Gessler, N 1998, 'Skeuomorphs and cultural algorithms', *Evolutionary Programming VII, Proceedings Of The Seventh International Conference On Evolutionary Programming*, Springer, Berlin, pp. 229-238.

References

- Gibson, JJ 1977, 'The theory of affordances', in RE Shaw and J Bransford (eds), *Perceiving, Acting, and Knowing*, Erlbaum, Hillsdale, New Jersey, NJ
- Gibson, JJ 1979, *The Ecological Approach to Visual Perception*, Houghton Mifflin, Boston, MA.
- Gibson, JJ 1982, *Reasons for Realism: Selected Essays of James J. Gibson*, E Reed and R Jones (eds), Erlbaum, Hillsdale, New Jersey, NJ.
- Grenby, MO and Immel, A (eds) 2009, *The Cambridge Companion to Children's Literature*, Cambridge University Press, Cambridge.
- Hedlund, J 2012, 'Apps and ebooks: A report from Bologna's tools of change conference', *SCBWI Bulletin*, July/August, SCBWI, Los Angeles, CA, pp. 22-3.
- Heidegger, M 1962, *Being and Time*, Harper and Row, New York, NY.
- Hourcade, JP 2008, 'Interaction design and children', *Foundations and Trends in Human Computer Interaction*, vol. 1, issue 4, ACM, Hanover, MA, pp. 277-392.
- Hourcade, JP 2015, *Child Computer Interaction*, <<http://homepage.cs.uiowa.edu/~hourcade/book/child-computer-interaction-first-edition.pdf>>.
- Hourcade, JP, Mascher, SL, Wu, D, and Pantoja, L 2015, 'Look my baby is using an iPad! An analysis of You Tube videos of infants and toddlers using tablets' Proceedings from CHI 2015, Seoul, Republic of Korea, ACM, <<http://dx.doi.org/10.1145/2702123.2702266>>.
- Innocent, T 2001, 'The language of Iconica', *Leonardo: Journal of International Society for the Arts Sciences and Technology*, June 2001, vol. 34, no. 3, pp. 255-259.
- Innocent, T 2003, 'Exploring the nature of electronic space through semiotic morphism', *Proceedings of the Melbourne DAC 2003*, RMIT Publishing, Melbourne, pp. 72-80.
- Innocent, T and Haines, S 2007, 'Nonverbal communication in multiplayer game worlds', *Proceedings of the 4th Australasian conference on Interactive entertainment*, article 11, RMIT University.
- Iser, W 1978, *The Act of Reading: A Theory of Aesthetic Response*, Routledge and Kegan Paul, London.

References

- Jenkins, H 2004 'Game design as narrative architecture' in N Wardrip-Fruin and P Harrigan (eds), *First Person: New Media as Story, Performance and Game*, MIT Press, Cambridge, MA, pp. 118-130.
- Jenkins, H 2006, *Convergence Culture: Where Old and New Media Collide*, New York University Press, New York, NY.
- Johnson, LF 1974, *Film: Space, Time, Light, and Sound*, Holt, Rinehart and Winston, New York, NY.
- Jung, H and Stolterman, E 2012, 'Digital form and materiality: Propositions for a new approach to interaction design research', *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, October 2012, ACM, pp. 645-654.
- Juul, J 2001, 'Games telling stories? A brief note on games and narratives', *Game Studies: The International Journal of Computer Game Research*, July 2001, vol. 1, no.1, article 45.
- Juul, J 2003, 'The game, the player, the world: Looking for a heart of gameness' in M Copier and J Raessens (eds), *PLUSAIS-Revista Multidisciplinar da UNEB*, no. 1, article 2.
- Kress, G and van Leeuwen, T 2001, *Multimodal Discourse: The Modes and Media of Contemporary Communication*, Oxford University Press, New York, NY.
- Kwastek, K 2008, *Interactivity - A Word in Process*, Springer-Verlag, Heidelberg,
<<http://dm.ncl.ac.uk/courseblog/files/2010/10/Interactivity---A-Word-in-Process.pdf>>.
- Latour, B 1993, *We Have Never Been Modern*, trans. C Porter (trans.), Harvard University Press, Massachusetts, MA.
- Laurel, B 2003 'The six elements and the causal relations among them', in Noah Wardrip-Fruin and Nick Montfort (eds), *The New Media Reader*, MIT press, Cambridge, MA, pp. 563-573.
- Laurel, B 2013, *Computers as Theatre*, 2nd edn, Addison-Wesley, Upper Saddle River, NJ.
- Locke J, 1996, *Some Thoughts Concerning Education and of the Conduct of the Understanding*, RW Grant and N Tarcov (eds), Hackett, Indianapolis, IN.
- Löwgren, J 1995, 'Applying design methodology to software development'. *Proceedings of the 1st Conference on Designing Interactive Systems: Processes, Practices, Methods and Techniques*, ACM, pp. 97-95.

References

- Löwgren, J 2014, 'Interaction design – brief intro', in M Soegaard and RF Dam (eds), *The Encyclopaedia of Human Computer Interaction*, 2nd edn, Interaction Design Foundation, Denmark.
- Löwgren, J and Stolterman, E 2004, *Thoughtful Interaction Design: A Design Perspective on Information Technology*, MIT Press, Cambridge, MA.
- Machell, B 2011 'How the fantastic flying books of Mr. Morris Lessmore took off', *The Times*, 23 July, viewed 29 July 2012, <<http://thetimes.co.uk/tto/arts/books/childrensbooks/article3101464.ece>>.
- Madej, K 2003, 'Towards digital narrative for children: From education to entertainment, a historical perspective', *ACM Computers in entertainment (CIE)*, vol. 1, no. 1, Article 3, October 2003, ACM, pp. 1-17.
- Markopoulos, P, Read, JC, MacFarlane, S and Höysniemi, J 2008, *Evaluating Children's Interactive Products: Principles and Practices for Interaction Designers*, 1st edn, Morgan Kaufmann, San Francisco, CA.
- Mayer, RE and Moreno, R 2002, 'Animation as an aid to multimedia learning', *Educational Psychology Review*, vol. 14, no. 1, March 2002, Plenum Publishing, pp. 87-99.
- McCloud, S 1993, *Understanding Comics: The Invisible Art*, HarperPerennial, New York, NY.
- McCullough, M 2004, *Digital Ground: Architecture, Pervasive Computing, and Environmental Knowing*, MIT Press, Cambridge, MA.
- McGrenere, J and Ho, W 2000, 'Affordances: Clarifying and evolving a concept', *Graphics Interface*, vol. 2000, pp. 1-8.
- McLean, K and Kulo, C 2013, *The Children's Book Consumer in the Digital Age*, Bowker Market Research.
- McLuhan, M 1968, *Understanding Media: Extensions of Man*, New American Library of Canada, Toronto.
- McLuhan, M 2011, *The Gutenberg Galaxy*, University of Toronto Press, Toronto.
- McQuillan M, 2000, *The Narrative Reader*, Routledge, London.
- Meeth, LR 1978, 'Interdisciplinary studies: A matter of definition', *Change: The Magazine of Higher Learning*, vol. 10, no.7, Special Issue: Report on Teaching.

References

- Merritt, S and Haas Dyson, A 1992, 'A social perspective on informal assessment: Voices, texts, pictures and play from a first grade' in C Genishi (ed.), *Ways of Assessing Children and Curriculum: Stories of Early Childhood Practice*, Teachers College Press, New York, NY, pp. 95-125.
- Mitchell, WJ 1995, *City of Bits: Space, Place, and the Infobahn*, MIT Press, Cambridge, MA.
- Moggridge, B 2007, *Designing Interactions*, MIT Press, Cambridge, MA.
- Mori, K, Ballagas, R, Reville, G, Raffle, H, Horii, H and Spasojevic, M 2011, 'Interactive rich reading: Enhanced book reading experience with a conversational agent', *Proceedings of the 19th ACM International Conference on Multimedia*, ACM, pp. 825-826.
- Munster, A 2011, *Materializing New Media: Embodiment in Information Aesthetics*, Dartmouth College Press, Hanover, NH.
- Munster, A 2014, 'Materiality', in ML Ryan, L Emerson and B Robertson (eds), *The Johns Hopkins Guide to Digital Media*, 2nd edn, Johns Hopkins University Press, Baltimore, USA, pp. 327-330.
- Murray, JH 1997, *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*, MIT Press, Cambridge, MA.
- Murray, JH 2003, 'Inventing the medium', in N Wardrip-Fruin and N Montfort (eds), *The New Media Reader*, MIT Press, Cambridge, MA, pp. 3-11.
- Murray, JH 2012, *Inventing the Medium: Principles of Interaction Design as a Cultural Practice*, MIT Press, Cambridge, MA.
- Nelson, TH 1965, 'A file structure for the complex, the changing and the indeterminate', *Proceedings of the 20th National Conference of the ACM*, ACM.
- Nikolajeva, M and Scott, C 2006, *How Picturebooks Work*, Routledge, New York, NY.
- Nodelman, P 1988, *Words About Pictures: The Narrative Art of Children's Picture Books*, University of Georgia Press, Athens, GA.
- Norman, DA 1988, *The Psychology of Everyday Things*, Basic Books, New York, NY.
- Norman, DA 1990, *The Design of Everyday Things*, Doubleday, New York, NY.

References

- Norman, DA 2004a 'Affordances and design', *Designing for People*, <http://www.jnd.org/dn.mss/affordances_and.html>.
- Norman DA 2004b, *Emotional Design: Why We Love (or Hate) Everyday Things*, Basic Books, New York, NY.
- Paivio, A 1986, *Mental Representations: The Dual Coding Approach*, Oxford University Press, Oxford.
- Propp, V 1968, *Morphology of the Folktale*, trans. L Scott, University of Texas Press, Austin, TX.
- Propp, V 1984, *Theory and History of Folklore*, A Liberman (ed.), trans. AY Martin and RP Martin, University of Minnesota Press, Minnesota, MN.
- Read, JC and MacFarlane, SJ 2000, 'Measuring fun-usability testing for children', *Computer and Fun 3*, BCS HCI Group, York, England.
- Rosa, AA 1994, 'The centre and the edges: Linguistic variation and subtitling Pygmalion into Portuguese', *Translation and the (Re) Location of Meaning, Selected Papers of the CETRA Research Seminars in Translation Studies*, vol. 1996, pp. 317-338.
- Rudd, D 2009, 'Animals and object stories', *The Cambridge Companion to Children's Literature*, MO Grenby and Andrea Immel (eds.), Cambridge University Press, Cambridge, pp. 224-.-257.
- Salen, K and Zimmerman, E 2004, *Rules of Play*, MIT Press, Cambridge, MA.
- Sargeant, B 2013, 'Interactive storytelling: How picture book conventions inform multimedia book app narratives', *Australian Journal of Intelligent Information Processing Systems*, vol. 13, no. 3, Special Issue on Edutainment 2013, AJIIPS, pp. 29-35.
- Sargeant, B 2015, 'What is an ebook? What is a book app? And why should we care? An analysis of contemporary digital picture books', *Children's Literature in Education*, vol. 45, issue 175, Springer.
- Sargeant, B and Mueller, F 2014, 'How Far is Up? Encouraging social interaction through children's book app design', *Proceedings of the 19th ACM CHI Conference on Human Factors in Computing Systems*, ACM, pp. 483-486.
- Schweinhart, LJ 1993, 'Significant benefits: The High/Scope Perry Preschool study through age 27'. *Monographs of the High/Scope Educational Research Foundation*, no. 10.

References

- Sim, G and Horton, M 2012, 'Investigating children's opinions of games: Fun Toolkit vs This or That', *IDC 2012 Proceedings*, Bremen Germany, ACM.
- Smeets, D 2012, 'Storybook apps as a tool for early literacy development', PhD thesis, University of Leiden, viewed 26 June 2013, <<https://openaccess.leidenuniv.nl/handle/1887/20363>>.
- Smeets, D and Bus, A 2013, 'Picture storybooks go digital: Pros and cons', in SB Neuman and SB Gambrell (eds), *Quality Reading Instruction in the Age of Common Core Standards*, International Reading Association, Newark, DE, pp. 176-189.
- Smeets, D and Bus, A 2014, 'The interactive animated e-book as a word learning device for kindergartners', *Applied Psycholinguistics*, vol. 22, no. 1, Cambridge University Press, pp. 1-22.
- Smith, BH 1981, 'Narrative versions, narrative theories', *On Narrative*, WJT. Mitchell (ed.), Chicago University Press, Chicago, IL.
- Steger, M 2011, *Ideologies of Globalisation*, Taylor and Francis Online, DOI: 10.1080/1356931052000310263.
- Suchman, LA 1987, *Plans and Situated Actions: The Problem of Human Machine Communication*, Cambridge University Press, Cambridge.
- Todorov, T 1981, *Introduction to Poetics*, trans. R Howard, University of Minneapolis Press, Minneapolis, MN.
- Tractinsky, N 2014, 'Visual aesthetics, in M Soegaard, Mads and RF Dam (eds), *The Encyclopedia of Human-Computer Interaction*, 2nd edn, The Interaction Design Foundation, Aarhus, Denmark.
- Tuan, YF 1977, *Space and Place: The Perspective of Experience*, University of Minnesota Press, Minneapolis, MN.
- VicHealth n.d., 'Why should I do the H30 Challenge?', *H30 Challenge*, viewed 10 January 2015, <<http://h30challenge.com.au/why>>.
- Whitbread, D 2009, *The Design Manual*, Revised and Expanded Edition, UNSW Press, Sydney.
- Wikert, J 2012, 'HTML5, EPUB 3, and ebooks vs. web apps', O'Reilly Tools of Change for Publishing, viewed 20 March 2013, <<http://toc.oreilly.com/2012/09/html5-epub-3-and-ebooks-vs-web-apps>>.
- Wiltse, H and Stolterman, E 2010, 'Architectures of interaction: An architectural perspective on digital experience', *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries*, ACM, pp. 821-824.

References

Winograd, T and Flores, F 1987, *Understanding Computers and Cognition: A New Foundation for Design*, Ablex, Norwood, NJ.

Wittgenstein, L 1953, *Philosophical Investigations*, Blackwell, Oxford.

Yellowlees Douglas, J and Hargadon, A 2000, 'The pleasure principle: Immersion, engagement, flow', *Proceedings of the Eleventh ACM on Hypertext and Hypermedia*, ACM, pp. 153-160.

Yokata, J and Teale, WH 2014, 'Picture books and the digital world: Educators making informed choices', *The Reading Teacher*, vol. 67, issue 8, pp. 577-585.

Zimmerman, J, Forlizzi, J and Evenson, S 2007, 'Research through design as a method for interaction design research in HCI', *Proceedings of Carnegie Mellon University Research Showcase*, ACM, pp. 493-502.

BOOK APPLICATIONS

Base Factory and AppBooks 2013, *Animalia* (Version 3.1), viewed 29 April 2014, <<https://itunes.apple.com/app/animalia-for-ipad/id388861927>>.

Busy Bee Studios 2014, *Even Monsters Get Sick* (Version 1.5), viewed October 2014, <<https://itunes.apple.com/app/even-monsters-get-sick/id535303119>>.

Disney 2011, *Don't Let the Pigeon Run this App!* (Version 1.1), viewed 5 May 2013, <<https://itunes.apple.com/app/dont-let-pigeon-run-this-app/id459749670>>.

Fox and Sheep GmbH 2013, *Nighty Night HD* (Version 4.0), viewed 10 January 2015, <<https://itunes.apple.com/app/nighty-night!-hd/id428492588>>.

Game College LLC 2010, *The Three Little Pigs and the Secrets of a Popup Book*, viewed 29 April 2013, <<https://itunes.apple.com/app/three-little-pigs-secrets/id407384876>>.

HarperCollins 2010, *The Heart and the Bottle* (Version 1.0), viewed 30 April 2012, <<https://itunes.apple.com/app/heart-bottle-for-ipad/id407795360>>

References

- Moonbot Studios 2011, *The Fantastic Flying Books of Mr. Morris Lessmore*, version 1.4, viewed 20 June 2014, <<https://itunes.apple.com/app/fantastic-flying-books-mr./id438052647>>.
- Nosy Crow 2013, *Little Red Riding Hood* (Version 1.0.7), viewed 25 June 2014, <<https://itunes.apple.com/app/little-red-riding-hood-by/id626696483>>.
- Sesame Workshop 2011, *The Monster at the End of this Book...Starring Grover!* (Version 4.3), viewed 23 June 2014, <<https://itunes.apple.com/app/monster-at-end-this-book...starring/id409467802>>.
- Tizio BV 2014, *Finn's Paper Hat HD* (Version 1.2), viewed 29 October 2014, <<https://itunes.apple.com/app/finns-paper-hat-hd/id438028726>>.
- We are Wheelbarrow 2013, *Rules of Summer* (Version 1.0), viewed 20 April 2014, <<https://itunes.apple.com/app/rules-of-summer/id705751146>>.
- What's the Fuss 2011, *Guess Who at the Zoo* (Version 1.1), viewed 29 April 2013, <<https://itunes.apple.com/app/guess-who-at-the-zoo/id489708348>>.
- Williams-Ng, S and Demibooks 2010, *Astrojammies* (Version 1.0), viewed 20 July 2013, <<https://itunes.apple.com/app/astrojammies/id408466505>>.

CHILDREN'S EBOOKS AND PICTURE BOOKS

- Comenius, JA 1976, *Orbis Sensualium Pictus: Facsimile of the Third London Edition*, Sydney University Press, Sydney.
- Meggendorfer, L 1979, *International Circus: A Reproduction of the Original Antique Pop-up Book*, Viking Kestrel, New York, NY.
- Newbery, J 2009, *A Little Pretty Pocket Book*, Dodo, Cornwall.
- Pieńkowski, J 1991, *Phone Book*, Orchard Books, London.
- Sargeant, B 2012, *Red*, Utates, New York, NY.
- Stone, J and Smolin, M 1971, *The Monster at the End of This Book*, Golden Press, Racine, WI.

Appendices

APPENDIX A: *HOW FAR IS UP?* THE EVALUATION STUDY

This is an edited excerpt from results relating to an evaluation study of *How Far is Up?* The full findings are pending publication.

The *How Far is Up?* application aims to foster both independent and shared reading experiences. This design provides an alternative to applications whereby an audio narrator or ‘digital tutor’ virtually replicates a physical adult. These pre-existing designs in effect make an adult redundant in shared reading situations. Alongside research assistants, I conducted a participant study in order to evaluate *How Far is Up?* I specifically wanted to understand children’s experiences of reading this application independently, and their experiences of reading it together with an adult. My research question, in conducting this participant study was:

How can we design children’s storybook applications so that they support both independent and shared reading experiences?

I recruited twenty-six participants from one kindergarten in Melbourne, Australia. Of the twenty-six participants there were: six three-year-olds (three girls, three boys); twelve four-year-olds (eight girls and four boys); and eight five-year-olds (four girls and four boys). The uneven number of girls to boys within the four-year-old category was due to absences on the days that the study was conducted. This application is primarily marketed towards four- and five-year-old children, yet it is believed that this work may also be suitable for three-year-old readers. For this reason, three-year-old children were included in this study.

Methodology

The study was conducted in the field in order to place minimal demands on the children involved (Markopoulos et al. 2008). This method allowed us to observe the participants in their natural setting, as the children are regular attendees of the kindergarten in which the study was housed. The evaluation involved a “children as users” method (Druin 1999, 2002). This entailed video-recording, photography, semi-structured interviews and participant observation (Markopoulos et al. 2008). These methods were used in order to understand the children’s experiences during independent and shared readings of *How Far is Up?*

The staff and children at the kindergarten in which the study was based do not normally use iPads in their daily routine. They do, however, use desktop computers in order to conduct their research activities. As a part of the kindergarten’s routine, the staff run a daily, structured storybook reading time. During this time, a teacher reads printed picture books to the children as a group. There are also informal individual and shared reading activities that are carried out in an unstructured way throughout the course of each kindergarten day. As a part of these informal reading activities, children are encouraged to read books independently, and staff also read stories with individual children.

It is known that children often read the same storybook multiple times (Merritt and Hass Dyson 1992). They also read them in numerous different ways: whilst alone, alongside friends, alongside siblings, with a parent or grandparent, at home or in a kindergarten. We could not evaluate the *How Far is Up?* design in each of these situations, so we chose to evaluate it in a manner that was typical within a kindergarten setting. As such, we gave the children the autonomy to direct the reading experience, as this is the way in which children typically engage in informal book reading activities within this and many other kindergartens.

Setup

Alongside research assistants, I visited the kindergarten a number of times prior to the study in order to meet with parents and to make the necessary arrangements with kindergarten management. During these visits, we met many children in the centre, and became somewhat familiar to them. Children who participate in studies have been known to give responses that they think will “please” the adults who are conducting the study (Hourcade 2015, p. 53). By establishing familiarity, we attempted to instil a degree of trust between the children and us; this may have helped facilitate a deeper level of honesty from the children during the study.

Prior to the study beginning, we set up cushions and pillows on the floor in a quiet area of the kindergarten known as the library. This area is one that is normally used for quiet reading. When a child entered the library area we did not direct them. We allowed them to sit or lie down in any place and in any way they wished within the given area. We focused the camera towards the child, rather than asking them to position themselves in front of a camera. This was with the aim of minimising the self-consciousness that cameras can elicit. We aimed to create the most comfortable, natural environment possible for the children involved. We observed and recorded the participants' behaviour and responses using both audio and visual devices and we also took handwritten notes during the study (2015, p. 58).

Procedures

The activities carried out in the study involved each child reading the *How Far is Up?* application independently, and reading it alongside an adult. Prior to reading, the children were asked a series of questions relating to their previous iPad usage. They were then given an iPad containing the *How Far is Up?* application. All of the children in the study chose to firstly read the application independently, and to then read it together with an adult. Two children started reading by themselves and partway through asked to read together with an adult.

During their reading sessions, we observed and recorded data relating to each child's response to the reading activities. For example, after each reading session we asked the children what they thought the story was about. At the conclusion of the study, the audio recordings were transcribed and the video footage analysed. All of the data, including our handwritten notes, were logged into a digital system. We then cross-referenced the materials gathered.

Findings

All of the names have been changed in order to preserve confidentiality.

Almost all of the children (twenty-four of twenty-six) had previously used an iPad. Of those who had used an iPad before, most (twenty of twenty-four) had only used it whilst they were alone. Two children reported having used an iPad with their siblings. One child reported that they once used an iPad with their mother, and one child reported that they used it regularly alongside their father in order to play games. These findings reinforce the notion that human interaction with computers mainly occurs in solitude (Munster 2011, p.

151). Potentially the children elected to start by reading the application independently as this related to their previous experience of using an iPad. Keeping in mind that only four out twenty-six children reported having ever previously used an iPad alongside others.

After reading the application independently, eighteen (of twenty-six) children could articulate what they thought the story was about; eight children could not articulate an interpretation of the story. Of these eight children, two were observed as being disengaged from the act of reading; they did not look at the imagery carefully, nor did they actively engage in the interactive features. Of the eight children who could not articulate the story after reading it independently, six were observed as being highly engaged in the act of reading.

In order to understand the different ways that the children approached the reading sessions, I will describe a few examples from the study. Four-year-old Jack talked to himself throughout his independent reading activity; supplying his own verbal commentary on the narrative action. For example, while reading independently, Jack said to himself: “He [Rusty] doesn’t know his spaceship is going away (laughter).” Yet at the end of the independent reading activity, Jack could not articulate what the story was about. As Markopoulos et al. explain, when asked, children “might not even know what they learned” as much of their learning happens in an “informal” way (2008, p. 30). After reading with an adult, however, Jack described the story by saying: “Sun is too high and too hot, they [characters] might melt. It’s the moon, a lot of the moon, it’s full.” While Jack was clearly highly engaged and able to follow the narrative events during his independent reading session, he could only articulate a verbal interpretation of the story after reading the application with an adult.

All of the twenty-six children could articulate what they thought the story was about after they had read *How Far is Up?* together with an adult. They all included the words “up”, “travel”, “space,” “sky,” “rocket” or “moon” in their descriptions. That is, they acknowledged that the story related to space travel or space objects.

When asked what they thought the story was about, the children recorded a variety of responses. For example, after reading *How Far is Up?* by herself, five-year-old Elsie (Figure 50) said the story was about: “How high can up be. Up to the moon, a swirling disc.” After reading with an adult, Elsie recorded a much more detailed account of the story using a total of thirty-seven words. She concluded with the statement: “Black holes are past the moon, they suck up planets. Reading makes you think.” Elsie’s understanding of the story was closely connected with ideas of space travel.

Three-year-old Joe showed a similar response to that recorded by Elsie. After reading independently, Joe succinctly declared that the story was about “Space.” After reading with an adult, he had a much more detailed response. He concluded by saying: “They see moons; like on that planet over there ...” He then picked up a globe of the world (one of the kindergarten’s regular objects) and spent

twenty minutes discussing his physical location on Earth, using the globe as a point of reference. Before Joe began his shared reading activity, he was visibly excited and appeared to have a clear idea that he was about to socially engage with an adult over this storybook. He stated, “OK. Let’s read a story.” Joe was highly engaged during both reading activities, he was able to clearly articulate his ideas on the narrative content after both reading sessions, and he had a firm expectation that the shared activity would offer social engagement.

In contrast to this, four-year-old Zac (Figure 51) could not articulate what the story was about after his independent reading time; when asked, he simply replied, “I don’t know.” After reading with an adult, Zac was able to describe the story by saying that: “They are in a rocket ship.” He then went on to discuss the stars in the story, comparing them to his experience of seeing stars while he was camping with his family. Although he did not use a large number of words to formally describe the story, Zac was quite articulate when relating *How Far is Up?* to his own lived experience. Our observations showed that Zac enjoyed and was engaged during his independent reading activity, and he may have formulated foundational story notions and personal story connections during this time, yet these ideas were only articulated after he had read together with an adult.

Some children displayed a close personal connection to the *How Far is Up?* story. For example, after reading independently, five-year-old Li said, “I think of being happy.” After reading with an adult, she described the story by saying that it was about: “Being happy and being cheeky. They didn’t ask their mum and dad about being up high. They saw a moon and sun. I learned that black holes eat lots of stuff.” Li related the story to her personal feelings and family relationships.

Other children described the *How Far is Up?* story by commenting on the characters’ relationships. For example, after reading independently, four-year-old Deepti (refer to Figure 52) said that the story was about “animals, they play with a kid.” After reading with an adult, Deepti said: “It’s about friends playing together a game. They play around in the sky and on the grass.” Deepti identified with the characters and their imaginative play activities.

During independent reading session, most of the children (nineteen of twenty-six) engaged in the counting activity that is featured in scene five of *How Far is Up?* Many children returned to and repeated this activity multiple times. The children’s responses to this animated interactive activity suggests that the design strategy, of presenting a refined level of animation and interactive features in order to direct users’ attention to a task, appears to have been successful. Rather than overloading users with excessive visual detail, this activity involves a simple eye-catching task that earned prompt and repeated attention from the large majority of participants.

There are difficulties in designing for adult participation in children's book applications. Adults "might not know which words to comment on or which events to discuss" (Smeets and Bus 2013, p. 185). In recognition of this, *How Far is Up?* provides content that may challenge young minds; as seen in the counting activity that appears in scene five of the application. Many children asked questions about the space objects or the written text associated with this activity. In providing a range of challenging content, this design appeared to provide adults and children with clear cues on how to engage in conversation over the conceptual territory presented.

Many of the five-year-old participants, who could be classed as being semi-literate, demonstrated that they could recognise specific words in the application's written text. The children displayed different ways of relating with written text. Where some children recognised words or enquired about word meanings, other children contributed their own text to the application. Two of the three-year-old boys and one three-year-old girl were observed writing the first letter of their name in the light blue "particle images" that are featured in scene nine of the application. The children involved in the study responded to the textual properties of *How Far is Up?* in a variety of ways.

When reading independently, five-year-old Lucy muted the application's music, saying: "it's too loud." After making this adjustment she was observed as being able to focus more fully on the story. No other children commented or muted any aspect of the audio. The music and sound effects appeared to operate as a positive addition to most of the children's reading experiences.

In summary, twenty-four of the twenty-six participants involved in the study were highly engaged in both the independent and shared reading activities. According to children's literary theory, a picture book designer should not aim to tell a didactic story which leads to a 'correct' or 'incorrect' narrative interpretation; these works should elicit imaginative reader responses (Nikolajeva and Scott 2006). In other words, stories mean different things to different people. Certainly our study indicates that *How Far is Up?* meant different things to different children. The participants described a variety of narrative interpretations while using some key words and concepts (moon, travel, space etc.) that were common to the group. Three-year-old Jinny appeared to articulate the collective feeling towards the application when she said: "I want to keep this one [the app] forever."

Figure 50
Five-year-old Elsie reading
How Far is Up? by herself.



Figure 51
Four-year-old Vlad reading
How Far is Up? by himself.



Figure 52
Four-year-old Deepti reading
How Far is Up? with an adult.



Limitations of the Study: Areas of Future Research

I acknowledge that this study has limitations, as do many studies that involve children. For example, none of the children involved in the study displayed verbal or physical signs that they were uncomfortable throughout the evaluation process. Yet, regardless of our efforts to conduct the study in a manner that may make the participants feel at ease, the children's behaviour may have been altered by our presence and through the act of them being observed and recorded.

These findings contain some qualitative evidence relating children's abilities to verbally articulate their interpretation of a story. After reading with an adult, all of the children in our study recorded a more detailed story articulation. We compared their experiences, yet acknowledge that further studies are needed. Future studies may compare children's ability to articulate storybook application narrative detail after reading independently, with their abilities to articulate these details after reading with an adult. These studies may occur across a range of different reading contexts and scenarios; counterbalanced approaches could shed further insights in this area.

Furthermore, future studies conducted in other settings, such as domestic and educational settings, involving guardians, siblings and teachers, may allow for further insights into how the design approach operates in the hands of users. Future studies could provide a more cohesive idea of how both adults and children can read and learn from storybook applications. Also, further studies could examine adults' responses to children's storybook applications, noting their willingness to read applications with children, and adult behaviours during these activities.

APPENDIX B: RELATED ACADEMIC PUBLICATIONS

Book Chapters

Sargeant, B 2014, 'Interaction design versus narrative flow in children's book apps: A practice-based empirical study', *SAGE Cases in Methodology*, SAGE, London.

Journal Articles

Sargeant, B 2015, 'What is an e-book? What is a book app? And why should we care?' *Children's Literature in Education*, vol. 45, issue 175, Springer.

Sargeant, B 2013, 'Interactive storytelling: How picture book conventions inform multimedia book app narratives', *Australian Journal of Intelligent Information Processing Systems*, vol. 13, no. 3, Special issue on Edutainment 2013, pp. 29-35, AJIIPS.

Conference Proceedings

Sargeant, B and Mueller, F 2014, 'How Far is Up? Encouraging social interaction through children's book app design', *Proceedings of the 19th ACM CHI Conference on Human Factors in Computing Systems*, pp. 483-486, ACM.

Sargeant, B 2013, 'Children's interactive narratives: How Far is UP?', *Proceedings of the 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death*, article 38, ACM.

Sargeant, B 2011, 'Anthropomorphism and morphism: Embodiment and the picture book', *Proceedings of ACUADS 2011 Conference, Creativity: Brain-Mind-Body*, The Australian Council of University Art and Design Schools.

APPENDIX C: RELATED CONFERENCE AND PUBLIC PRESENTATIONS

- 2015 'Social Interaction Over Shared Devices: Designing Interactive Story Apps for Children', Keynote presentation /dev/world 2015, industry conference, Melbourne, AUSTRALIA
- 2014 'How Far is Up? Encouraging Social Interaction Through Children's Book App Design', conference demonstration and exhibit, *Interactivity, CHI2014*, Toronto, CANADA
- 2013 'Children's interactive narratives: How Far is Up?' conference demonstration and exhibit, *Australasian Conference on Interactive Entertainment (IE)*, Melbourne, AUSTRALIA.
- 2013 'How Far is Up?' industry presentation, *Click on kids: Children's International Digital Publishing Seminar*, Australian Publishers Association, Sydney, AUSTRALIA.
- 2013 'The practice of privileging literature within interactive multimedia digital books for children'. international conference presentation, *21st Congress, International Research Society for Children's Literature*, Maastricht, THE NETHERLANDS.
- 2013 'A history of playful book design for children' invited speaker, RMIT, GEELab, Karlsruhe, GERMANY.
- 2013 'Immersion and children's digital books', invited speaker, *The Writing Society and Research Centre (University of Western Sydney) International Seminar*, Reges Hotel, Sydney, AUSTRALIA.
- 2013 'Book apps and legacy media: How the humble picture book informs interaction design', international conference presentation, *19th International Symposium of Electronic Art (ISEA 2013)*, Sydney, AUSTRALIA.
- 2013, 'How the humble picture book informs interaction design', invited speaker, *Digital Humanities International Symposium: Transformations of the Image and Text*, Hosted by the University of Western Sydney, Sydney, AUSTRALIA.
- 2013 'In conversation with Betty Sargeant - Writing and illustrating in the digital age' industry presentation, *In Conversation Program*, Australian Society of Authors, Wheelers Centre, Melbourne, AUSTRALIA .
- 2012 'Has illustrating changed in the digital age?' panel chair, *Ballarat Writers and Illustrators Festival*, Ballarat, AUSTRALIA.
- 2011 'Anthropomorphism and morphism: Embodiment and the picture book', conference presentation, *The Australian Council of University Art and Design Schools (ACUADS)*, Canberra, AUSTRALIA.

APPENDIX D: RELATED AWARDS AND ACCOLADES

- 2015 Awarded an ISS (International Specialised Skills Institute) Fellowship: The Melbourne Knowledge Fellowship.
- 2015 Shortlisted for a CHASS (Council for the Humanities, Arts and Social Sciences) prize. Winner announced October 2015.
- 2015 Shortlisted for a Consensus Innovation Award for *How Far is Up*. Winner announced October 2015.
- 2015 Won AIMIA (Australian Digital Industry Award) finalist award for *How Far is Up*.
- 2014 Shortlisted for a Victorian Premier's Design Award for *How Far is Up*.
- 2011 Awarded an Australian Post-Graduate Award (APA Scholarship) for PhD Studies.
- 2011 Awarded an RMIT PhD Scholarship.
- 2011 Awarded the *Varuna Writer's House Second Book Fellowship*.
- 2011 Finalist in the RMIT *Three Minute Thesis* Competition
[Winner of the RMIT College of Design and Social Context heats of this competition].

APPENDIX E: HOW FAR IS UP? NASA MEDIA CREDITS

- Figer, D and NASA 1999, The Quintuplet Star Cluser, 21 September, R Nemiroff and J Bommell (eds), NASA, <http://www.nasa.gov/multimedia/imagegallery/image_feature_557.html>.
- GSFC n.d. The Milky Way Galaxy – Home to Many Planets, Solar System Exploration, NASA, <http://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=323>
- Kohle, S and Kohle B and NASA 2002, A Perseid Meteor, 11 August, R Nemiroff and J Bommell (eds), NASA, <<http://apod.nasa.gov/apod/ap020811.html>>.

NASA, CXC, M. Weiss 2014, Artist Impression of Binary System Containing Stellar-Mass Black Hole, February 21 2012, <<http://www.nasa.gov/content/chandra-finds-fastest-wind-from-stellar-mass-black-hole/#.VOQm0ydPLpU>>.

NASA, JPL and USGS 1998, Hemispheric View of Venus Centered at 270° East Longitude, 4 June, NASA Jet Propulsion Laboratory, <<http://jpl.nasa.gov/spaceimages/details.php?id=PIA00160>>.

NASA, JPL-Caltech and UMD 2005, Separation Anxiety Over for Deep Impact, 7 March 7, S Watanabe (ed), NASA, <http://www.nasa.gov/mission_pages/deepimpact/multimedia/imp-mri-070305.html>.

NASA, JPL-Caltech and University of Toledo 2006, Spitzer Digs up Treasures of Possible Solar System in Orion, 4 August, NASA, <<http://jpl.nasa.gov/news/news.php?release=2006-099>>.

NASA 2003, The Sun Emits Radiation, 21 October, K Dismukes (ed), NASA, <<http://spaceflight.nasa.gov/shuttle/support/researching/radiation/brochure1/>>.

NASA 2004, 'Comet NEAT', in I Gilman (ed) Comet, 7 May, NASA, <http://www.nasa.gov/audience/forstudents/nasaandyou/home/comets_bkgd_en.html>.

NASA 2004b, Mountains on Mars are Much Larger than Earth Mountains, R Chohan (ed), NASA, <http://www.nasa.gov/vision/earth/environment/Sibling_Rivalry.html>.

NASA 2007, NASA Prepares for Performing New Science on the Moon, 21 June, Jet Propulsion Laboratory, NASA, <<http://jpl.nasa.gov/news/news.php?release=2007-068>>.

NASA 2008, Image of the Day Archives, in J Wilson (ed), NASA Image Archive, <http://www.nasa.gov/multimedia/imagegallery/iotd_archive.html>.

NASA 2008b, S124-E-008613, 10 June, STS-124 shuttle mission imagery, NASA, <<http://spaceflight.nasa.gov/gallery/images/shuttle/sts-124/html/s124e008613.html>>.

NASA 2012, City Lights of Australia or Not, 20 December, Paul Przyborski (ed) NASA Earth Observatory, <<http://earthobservatory.nasa.gov/IOTD/view.php?id=80030&src=ve>>.

NASA 2012, Night Lights 2012-Flat Map, 23 October, NASA Earth Observatory, <<http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=79765&src=ve>>.

NASA, Mitchell-Ryan, R and Farrer, T 2009, Kepler Launch in 2009, NASA, <http://nasa.gov/multimedia/imagegallery/image_feature_2123.html#.VOQghydPLpV>.

NASA and Springel V 2013, Starry Night Tango, 19 May, NASA, <https://youtube.com/watch?v=8mFN_cDek1w>.

Simmon, R 2012, City Lights of the United States 2012, 18 April, NASA Earth Observatory, <<http://visibleearth.nasa.gov/view.php?id=79800>>.