School of Design and the Built Environment

A Model for Mapping Interactivity in Learning Experiences

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature of Candidate: ____

Date: 15 March 2018

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Publications associated with this research

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Tay, Jo Li. 2015. "Interaction, Interface and Interactivity." In *Australian Council of University Art & Design Schools (ACUADS) Conference, Melbourne, Victoria, 2-3 October 2015*. http://acuads.com.au/conference/article/interaction-interface-and-interactivity/.

Abstract

This research is situated at the intersection of technology, education, and design. Technology has changed rapidly in the last two decades. This, in turn, has made it difficult for technology use in education to keep pace. For this same reason, academic research relating to technology has generally lagged behind industry research, as has the adoption of a whole-world perspective to make sense of technology, its uses, and its impacts on society, especially in an educational context.

A design thinking (research through design) approach was applied to examine the various aspects of this issue, and the relationships between these. Following the literature review, it became apparent that the focus of this research project needed to be on the aspect of **interactivity**, as it was common across all the different aspects.

Existing academic research, however, has tended to focus on specific elements or areas of interactivity, instead of the wider relationships that exist between them. These attempts to define interactivity are also relatively scarce and isolated, and are scattered across disparate disciplines. Fornäs (1998, 33) observed,

> Studies combining several perspectives are needed to clarify the connections, similarities and differences between the various types of interactivity enabled by [different forms of media].

This research is one attempt at doing so, and does so in the context of learning and education. It proposes a working definition of **interactivity aesthetics** that can be used across multiple disciplines, and produces a model of interactivity as a practical means of evaluating the interactivity in any given learning experience. The iterations of the model were tested by the researcher using a set of nine scenarios, and the final model was tested on an additional three Learning Experience Scenarios. Due to the limitations of this, it is proposed that further research be conducted, in which other researchers and users are recruited, and additional scenarios are used, in order to refine the model further.

It is hoped that this model can help to improve the understanding of interactivity (e.g. what it is, how it works, and how it can be used to improve learning), and thus enable educators to get the maximum benefits from technology.

Contents

01

INTRODUCTION

Background

This research began as an investigation into how aesthetics can affect learning—in particular, how the application of Web 2.0 aesthetics to learning materials would impact learning. Thus, the initial research focused on Web 2.0 aesthetics, as well as visual literacy, visual aesthetics, and instructional design. The term Web 2.0 aesthetics is generally used to refer to the visual aesthetics of Web 2.0 instructional design materials (including websites, educational computer games, and iPad apps). It was initially considered to be a suitable umbrella term that could be used to refer to the combination of visual aesthetics and non-visual (or interactive) aesthetics. However, while investigating Web 2.0 aesthetics, it became clear that usage of the term Web 2.0 was waning (Wauters 2009). It also became apparent that delineating between the visual and non-visual was flawed—this delineation reflected a societal and historical bias toward the visual[1], and did not accurately represent how we experience the world. The abundance of research into visual aesthetics and the dearth of research into interactivity aesthetics indicated that the latter warranted further investigation, so the literature review was subsequently expanded to include interactivity. This led to the adoption of the perspective that we experience the world around us through interactivity, and that the visual is simply one aspect of interactivity, not separate from it. Thus, interactivity began to assume a more central role in this research.

This focus on interactivity is timely given the dramatic speed at which technology has changed in the last two decades, with touchscreen mobile devices[2] becoming widespread in the last seven or eight years. However, the rapidity of these recent changes often means

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1 That is, for the majority of us who are not visually impaired, which says a lot about our consideration of the minority who are.

2 These are often referred to as interactive devices.

playing catch-up—academic research in technology-related fields (such as user interaction, experience design, human-computer interaction) frequently lags behind industry research. In some instances, changes occur so quickly that published academic research can be rendered obsolete or irrelevant within a few years. Amidst this whirlwind of change, trying to make sense of the complexities of technology and its offerings from a whole-world perspective is a low priority task. This is no less true with interactivity, which tends to be overlooked more than investigated. Yet to get the maximum benefit from technology, a better understanding of interactivity is necessary—what it is, how it works, and how it can be used to improve learning. Attempts have been made to define interactivity, but these are relatively scarce and isolated, as well as being scattered across disparate disciplines. Consequently, it is clear that the development of a working definition of both interactivity and interactivity aesthetics is needed.

In order to achieve a better, more well-rounded understanding of interactivity and interactivity aesthetics, the literature review spans the breadth and depth of a number of disciplines—including neuroscience, instructional design, education, human-computer interaction, user interface design, user experience design, and philosophy. It also brings together a number of seemingly unrelated topics: aesthetics, interactivity, education, learning, literacy, visual literacy, emotions, instructional design, experience design, neuroscience, and technology. This approach has contemporary relevance. As we move towards multi-disciplinarity, cross-disciplinarity, inter-disciplinarity and trans-disciplinarity, there is increasing value in research that draws connections between different disciplines, especially when concepts, models and frameworks are frequently only examined and applied within the discipline from which they originated.

The need to understand the relationships between various disciplines (e.g. similarities, differences, contradictions, etc.) is important. Without a bird's-eye view of the relationships between disciplines, research is likely to occur primarily within the individual disciplines themselves. One negative result of this is the use of different terminology across disciplines (i.e. what one discipline calls A, another might call B), another is what can be referred to as 'oblivious duplicity' (i.e. a lack of awareness of similar research because it is from a different discipline). With regard to interactivity, much of the academic research that exists is focused on specific elements or areas of interactivity, instead of the wider relationships that exist between them. As Fornäs (1998, 33) pointed out, "Studies combining several perspectives are needed to clarify the connections, similarities and differences between the various types of interactivity enabled by [different forms of media]." This research is one attempt at doing so.

Aims and objectives

The aims of this research are twofold: first, to develop a working definition of interactivity aesthetics that can be used across a broad range of disciplines; and second, to translate this definition into a means of evaluating the interactivity in any given learning experience. To achieve the two aims described above, the following are the objectives of this study:

» To review academic and industry-generated literature and identify existing models relating to interactivity, aesthetics, and instructional design.
» To use the findings from the literature review to generate a working definition of interactivity aesthetics.
» To translate the definition of interactivity aesthetics and the findings from the literature review into a format that can be used to evaluate the interactivity in any given learning experience.

With regard to the last objective, it is expected that the format used to evaluate interactivity in learning experiences should:

» Be able to readily display the various dimensions of interactivity and the relationships between these;
» Be versatile enough to work across a wide variety of disciplines and experiences;
» Allow the interactivity in different experiences to be compared; and
» Do all of the above as simply as possible.

A design thinking methodology was used to achieve the aims and objectives of this research The detailed description of the methodology used here is contained in Chapter 3. Overall, the main stages in this research mirror the design thinking process outlined by Zimmerman, Forlizzi, and Evenson. A literature review of existing research was first conducted across a broad range of relevant disciplines. This is found in Chapter 2. Chapter 4 presents the working definition of interactivity aesthetics and the key influences and insights from the literature review that were used to inform the model of interactivity. Chapter 5 contains the ideation, iteration, and critique of the different versions of the model. There were five distinct versions of the model altogether. Chapter 6 presents the final model of interactivity. Chapter 7 evaluates the usability of the final model by applying it to three Learning Experience Scenarios. Chapter 8 contains the discussion and recommendations relating to the model, including proposed future research. Chapter 9 concludes with a summary and overview of the research as a whole.

Significance

Andreas Wagner, an evolutionary biologist, explained that although some revolutions challenge existing theories, others "leave core elements of previous theories intact" and "add layers of clarity and resolution, as well as new dimensions" instead (Wagner 2015, 28). The latter approach underlies this research. The purpose of this research is not to disprove or debunk the work of other theorists and researchers, but to build on it and, in doing so, improve our understanding of interactivity as well as prompt new thoughts and research. An investigation into existing models and frameworks found that they tended to be linear or they lacked the level of complexity required to show the relationships between the various elements of interactivity. None of the models or frameworks provided a 'snapshot' overview of the interactivity present in a given learning experience (or any experience, for that matter). The model of interactivity developed in this research is significant not only because it allows the mapping of interactivity, but also because it is specifically designed to be versatile enough to map the interactivity in a range of different experience types. This means it can be used across a variety of disciplines, and can thus provide a common ground for those disciplines.

The model of interactivity is also of significance in the context of visual aesthetics, and in the more general concepts of aesthetics and sensory perception. Namely, it addresses the gap in aesthetics that is the result of our limited ability to articulate mental imagery in sensory modes other than the visual[3]. The creation of a mental image is much more complex than just 'seeing in the mind's eye'. Watching a live concert is not the same as watching it on television at home,

[3] As Thomas (2014) pointed out, "The English language supplies quite a range of idiomatic ways of referring to visual mental imagery: 'visualizing [sic],' 'seeing in the mind's eye,' 'having a picture in one's head,' 'picturing,' 'having/seeing a mental image/picture,' and so on. There seem to be fewer ways to talk about imagery in other sensory modes, but there is little doubt that it occurs, and the experiencing of imagery in any sensory mode is often referred to as 'imagining' (the appearance, feel, smell, sound, or flavour [sic] of something)".

and looking at a photo taken during a family holiday by the beach is not the same as being at the holiday itself. The model of interactivity presented in this research is the first step toward establishing how the different combinations of interactivity present in different experiences can result in a different aesthetic quality each time (i.e. what is referred to in this research as 'interactivity aesthetics'). The model of interactivity is intended to function as a means of facilitating a more holistic and complete understanding of interactivity across different disciplines, thus providing a common foundation across these disciplines upon which more complex structures can be built.

The introduction of interactivity aesthetics is meant to complement the past and present work in visual aesthetics, rather than act as a replacement. The aim is to provide a method of analysing the aesthetics of experiences that is potentially richer and more inclusive. In the context of education, a better understanding of the role of interactivity aesthetics in learning is integral to the development of learning materials for current and future students. This research also has a wider significance in its contribution to the body of research on e-learning design, particularly in distance learning. It also contributes towards the study of aesthetics in education. Such knowledge will be invaluable to not only the Australian education community, but the global education community as well.

In addition to education, this research is of value to a plethora of other contexts, including entertainment (e.g. video games), commerce (e.g. retail), and science (e.g. robotics). Reframing these existing disciplines through a common lens of interactivity will give us more profound (and less binary) ways of perceiving human experiences. This expanded view is significant not only because it could potentially help identify the interactivity dimensions linked to a specific learning outcome in education, but also because at a broader level it could allow us to determine the combination of interactivity dimensions required to produce a specific experience. For instance, a greater understanding of interactivity aesthetics and the dimensions of interactivity can offer further insight into how to effectively use virtual reality to create quality medical simulations.

Key terms

The definitions of the key terms provided here have been summarised and edited for conciseness. Lengthier discussions of these terms can be found in Chapter 2.

Literacy

The definition of literacy adopted in this research is derived from Macedo and Steinberg (2007, 4–5), who defined literacy as "gaining competencies involved in effectively learning and using socially constructed forms of communication and representation". This is taken to include "the skills and knowledge to read, interpret, produce texts and artifacts, and to gain the intellectual tools and capacities to fully participate in one's culture and society".

Visual literacy

The definition of visual literacy adopted here is drawn from Bamford (2003). Visual literacy is understood as referring to a person's ability to "read and write visual language". Thus, a visually literate person is able to "decode and interpret visual images" (reading) and "encode and compose meaningful visual communications" (writing).

Digital natives

In this thesis, digital natives refers to the term coined by Marc Prensky (2001). It includes those who have been born and raised in an environment where digital devices have always been present, and are distinct from those who have only had exposure to digital devices later in their lives. According to Prensky, there are marked differences between those born into the present-day digital world and those who are merely “immigrants”.

Interactivity

The definition of interactivity in this thesis draws on the ideas proposed by Förnas (1998), Gee (2007), Sohn (2011), and Steuer (1992). Interactivity is taken to refer to the *state of doing* that exists during an experience. It is not the ability to elicit change in the form or content of an experience, nor is it viewed as describing the quality of an experience. Interactivity encompasses both the intended interactivity (if planned by a designer or creator) and the actual interactivity present in an experience. Additionally, interactivity does not have to involve a two-way exchange to be present—that is to say, interactivity is present whether or not changes occur during or as a result of the experience. This means interactivity is present even if you interact with something—be it a person or an object or a place—that does not (or cannot) respond, for example, when you read a book or view a painting.

Aesthetics

The overall approach to aesthetics in this thesis acknowledges the controversy surrounding its definition. However, the definition adopted here takes it a step further by proposing that aesthetics should be seen as being universally present, even if there is a lack of consensus with regard to its meaning. Although aesthetics is influenced by the fields of philosophy and art, it should not been seen as existing only within these; in other words, aesthetics is understood to be present in all experiences.

Furthermore, it is also proposed that aesthetics be used as a means to describe aesthetic experience, through the use of both internalist and externalist approaches. The internalist approach is phenomenological and considers the aesthetics of the experience based on how it is perceived by the person engaged in the experience, while the externalist approach is more objective, and considers the aesthetics of the actual features of the experience.

Active learning and constructivism

Constructivism is a learning theory. It posits that in any learning situation, the learner constructs new knowledge based on existing knowledge they have, acquired from prior experience. This means that, even if given the same learning situation, the learning experience of each learner is different, and what each individual learns is unique. Constructivism underpins the concept of active learning. The interpretation of active learning used here draws from Prince (2004). Active learning is thought to occur when the learner constructs new knowledge structures as a result of one or more of the following: depth of learning, problem-solving, generative production (e.g. an essay, a product), discourse (or discussion), personal autonomy (including self-direction and self-reflection), and collaboration (which includes co-operation).

Instructional design

The definition of instructional design used here is taken from Gagné et al. (2005). Instructional design refers to the process by which activities are selected, created, organised, planned, and applied for the purpose of learning. This includes "selecting materials, gauging student readiness to learn, managing class time, monitoring instructional activities" (Gagné et al. 2005, 1). Or, as Reiser (2001, 58) described it, a process that includes "the analysis of instructional problems, and the design, development, implementation and evaluation of instructional procedures and materials intended to solve those problems".

02

LITERATURE REVIEW

"As I learned more about how these early role-playing games worked, I realized that a D&D module was the primitive equivalent of a quest in the OASIS. And D&D characters were just like avatars. In a way, these old role-playing games had been the first virtual-reality simulations, created long before computers were powerful enough to do the job. In those days, if you wanted to escape to another world, you had to create it yourself, using your brain, some paper, pencils, dice, and a few rule books."

(Cline 2011, 66)

The literature review is divided into six sections, each of which explores the significant information linked to the following key areas and are named accordingly:

» Aesthetics;
» Interactivity;
» Learning;
» Emotion; and
» Related visual models.

"Aesthetics" looks at the role and origins of the term aesthetics, philosophical theories on aesthetics and aesthetic experience, and the application of aesthetics in instructional design and technology. "Interactivity" examines and discusses existing interpretations of both interactivity and interactivity aesthetics. It also explores the evolution of interactivity in communication media and in design, as well as the role of interactivity in simulation, immersion, and presence. "Learning" explores and discusses the relationships between learning and education, learning and literacy, and learning and technology. "Emotion" reviews the central role that emotion plays in everything we do, including learning. It also looks at the relationship between aesthetics, emotion, and learning. "Related visual models" presents the visual models that informed the development of the model of interactivity.

Aesthetics

As someone with Eastern roots—I am ethnic Chinese and grew up in South-East Asia—but who has now lived most of my life in a Western country, I have realised that this background places me in a unique position with a unique perspective, in which my thinking automatically blends both Eastern and Western-based philosophies. In some way, this section reflects this. It focuses predominantly on Western-based philosophies relating to aesthetics, in an attempt to identify the minority of philosophies (e.g. Dewey) that adopt the holistic approach common in many Eastern-based philosophies, and in my own cultural background, so as to compare and contrast them with the dominant Western philosophies of the time. The section begins with "The role of aesthetics", which explores the current and historical perspectives of aesthetics, including the complex and contentious relationship between aesthetics, art, and science. "Philosophical theories on aesthetics" provides an overview of analytic philosophy and pragmatism, the concepts of experience and aesthetic experience, as well as internalism and externalism. "Aesthetics in instructional design" looks at the role of aesthetics in instructional design. Lastly, "Technology and aesthetics" examines the role of aesthetics in human-computer interaction, including work on the aesthetics of interaction.

The role of aesthetics

Since Greek philosophers first discussed the concept of aesthetics, views on aesthetics have varied widely. At one point, aesthetics was considered to be so unimportant that it was often the last factor to be considered—and the first to be discarded—in nearly all aspects of daily life, industry, and academia (with the possible exception of the arts). This no longer seems to be the case—aesthetics is now increasingly a topic of interest in many disciplines. The growing importance of aesthetics has seen it become "neither higher nor lower than 'real' life" but "part of it" (Postrel 2004, xv). The ascendance of aesthetics has also prompted changes in the contexts in which aesthetic discourse occurs. These days, aesthetics is no longer exclusively the subject of academics, artists and philosophers. Discussions about aesthetics are just as likely to happen between two people in a furniture store as they are between two academics at an art college. "Aesthetics," wrote Postrel (2004, 4), "has become too important to be left to the aesthetes." To understand why this is, it is necessary to examine the conceptual origin of aesthetics and its evolving relationship with art and science.

The conceptual origin of 'aesthetics' can be traced to Greek philosophy, although they did not actually use the term 'aesthetics' (Brown 2010). Greek philosophers spoke of "perception through the senses" or, in the case of Aristotle, "perception in relation to form" (26). Because the ancient Greeks could only rely on what they saw, heard, touched, smelled, or tasted, to perceive objects and their surroundings, for them perception was tied to direct sensory experience. This made it challenging to discuss and represent abstract concepts that could not be explicitly described in words (e.g. human emotions), and was a source of controversy. On the one hand, philosophers such as Aristotle believed form (or art) could be used to represent abstract concepts (such as human emotion), while others, like Plato, thought art was an "imperfect and, therefore, corrupt copy of reality". (Brown 2010, 26)

In the eighteenth century, Alexander Baumgarten addressed this dichotomy between the representation of concrete and abstract concepts. He introduced the term 'aesthetics' and referred to it as the "science of sensory cognition [*scientia cognitionis sensitivae*]" (Fenves 2002, 339). Baumgarten believed that the mental effort expended to interpret sensory information (e.g. imagery) was equal to the effort expended in logical and scientific analysis (Guyer 2014). He also suggested that it was possible to represent information acquired through sensory input in two ways: by increasing the *clarity* of the individual components that constitute the sensory input (*claritas intensive maior*), or by increasing the *number* of individual components (*vividitas*, *claritas extensive maior*, *cogitationum nitor*). The former produces proofs (or analytical clarity), while the latter produces richness of imagery (or liveliness). It is the latter which forms the basis of aesthetic experience. (Guyer 2014)

Despite Baumgarten's attempt to establish aesthetics as a science, our understanding of aesthetics today is more closely affiliated to art than science. The online version of Merriam-Webster dictionary, for example, defines aesthetics as "a branch of philosophy dealing with the nature of beauty, art, and taste and with the creation and appreciation of beauty"; "a set of ideas or opinions about beauty or art"; "the study of beauty especially in art and literature"; and "the artistic or beautiful qualities of something". The online version of Oxford Dictionaries has similar definitions: "a set of principles concerned with the nature and appreciation of beauty" and "the branch of philosophy which deals with questions of beauty and artistic taste." Thus, it is not unreasonable to suggest that, for most people, aesthetics generally relates to beauty, artistic taste or the sensual qualities of an object. In fact, even contemporary academic writing on aesthetics generally focuses on art and taste, rather than on science (Brown 2010; Stecker and Gracyk 2010). Brown (2010, 26), for instance, called aesthetics "a philosophy, a literary and artistic movement, a design ideal, and a practical consideration".

This association of aesthetics with art can partly be attributed to the separation of the arts from the sciences. Before the existence of modern science, the Greeks primarily used philosophical reasoning to determine truths about the world (Cheung and Brach 2011, 7). This was based on logic and observation. Aristotle, for example, "trusted personal observation and hands-on experience as the bedrocks of the scientific method he developed and wrote about" (Levinson 2001, 18-19). This method of scientific inquiry remained dominant in Europe for over two thousand years, in part because of the rise of the Christian Church in Europe during which the pursuit of scientific inquiry came with the risk of being declared a heretic and executed (Cheung and Brach 2011, 9-10). Essentially, there was no clear delineation between the arts and the sciences, and up until—and during—the Renaissance "the philosophies of art, architecture, engineering and science were comprehended by all intelligent people" (Ashley-Smith 2000).

The Renaissance brought a renewed interest in the pursuit of knowledge and truth, which saw a new methodology emerge. This new methodology required "researchers to follow a disciplined and objective process" and was called the scientific method (Cheung and Brach 2011, 9-10). As the Renaissance gave way to the Enlightenment, the scientific revolution that began in the 1500s and 1600s saw a surge of intellectual activity focused on three distinct realms: the True (science), the Good (politics, ethics and religion), and the Beautiful (aesthetics) (Bristow 2011). This saw ideology, science, and art—once unified under philosophy—become segregated into separate disciplines. Over time, each of these saw further division into an increasing number of specialties. As each specialty focused on deepening the knowledge in their area, the holistic view once tied together by philosophy became fractured[4]. This fostered the "image of the sciences and the arts as separated or even as diametrically opposed" (Williams 2015).

The Enlightenment also hosted a number of philosophical ideas that would later underpin the belief that science and art were separate entities. The first of these is John Locke's concept of the 'blank slate', a translation of the original Latin term *tabula rasa*. Locke proposed this in response to the theory that people were born preloaded with "mathematical ideals, eternal truths, and a notion of God" (Pinker 2003, 5). Locke's 'blank slate' led to French philosopher René Descartes' proposition that even though the mind and body are connected, they are nonetheless separate, so the mind can continue to exist even if the body (or parts of it) does not. In other words, human behaviour is not caused by external or internal events, but is consciously chosen by the mind; in effect, we are our minds. (8-9)

Descartes' theory was dismissed three centuries later by another philosopher, Gilbert Ryle, who referred to it as "the dogma of the Ghost in the Machine" (Pinker 2003, 9). It was subsequently

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[4] In practice it is all but impossible for an individual researcher to acquire and retain in-depth knowledge about such a broad range of disciplines simultaneously, for a number of reasons. Firstly, any research conducted would have required the physical presence of the researcher, and as a person could not be in two places at once, it was logistically impossible for anyone to participate in more than one research study at a time. (Instantaneous forms of communication such as email and social media did not yet exist.) Secondly, it is quite likely that scientists mingled with other scientists, and artists with other artists. Assuming a lack of social interaction between scientists and artists—this is presumed, thus far there does not seem to be any accounts clarifying whether or not such interaction took place—the exchange of ideas between artists and scientists would have been limited; this was surely compounded also by the lack of a common set of terminology that traversed the two fields. Thirdly, one would also presume that it would have been difficult for an individual to retain the volume of information required to have an in-depth knowledge of multiple disciplines across the arts and sciences; one might say it is the equivalent of memorising the entire contents of the World Wide Web.

also refuted by contemporary neuroscience (Damasio 2008). However, by the time this happened, the mind had already achieved a superior status, thanks to the ideas proposed by Locke and Descartes. This dominance of mind over body saw logical thought and reasoning achieve a similar rise in status. Accordingly, their role in the scientific method saw science become increasingly relied upon to determine truths about the world. Then as modern analytic philosophy aligned itself with science and promoted the notion that "the ideal and paradigm of human achievement was … science" in the nineteenth century, an attempt was also made "to apply the logically rigorous and precise methods of scientific philosophy to the wayward and woolly realm of art" (Shusterman 1992, 11). Unsurprisingly, this failed. This failure saw art and aesthetics "accorded marginal status and often intentionally skirted as hopelessly beyond the scope of scientific understanding". (11)

The consequence of this was that art and aesthetics came to be viewed as being the opposite of science, having been as established as being free from function, unfettered by logic and reason, and characterised by ambiguity (Shusterman 1992). By the mid-twentieth century, science and art were clearly divided (Snow 1959). Today, public perceptions of science and the arts are directly oppositional. Sousa and Pilecki (2013, 9) recently highlighted this in the form of a table—they show that while STEM (which stands for Science, Technology, Engineering and Math) is considered objective, logical, analytical, reproducible and useful, the Arts, by comparison, is seen as subjective, intuitive, sensual, unique and frivolous.

In recent years, however, there has a shift toward a view that the relationship between science and the arts is complementary, not oppositional. This includes those who advocate moving from STEM to STEAM, where STEAM is an adaptation of STEM that has an added 'A' for Arts. In *From STEM to STEAM: Using Brain-Compatible Strategies to Integrate the Arts*, authors Sousa and Pilecki (2013, 10) wrote, "Arts and sciences do not compete; they are complementary. The arts create a very subjective view of the world, while science creates an objective view of the world. A person's brain needs both views in order to make suitable decisions." Sousa and Pilecki are part of a growing community of researchers who believe that art and science should work in partnership—not in competition—with each other. Maeda (2013), for example, proposed that the subjectivity of the arts promotes divergent thinking while the objectivity of the sciences promotes convergent thinking and, together, they allow innovation to occur. Piro (2010) pointed to empirical evidence showing the arts can help improve cognitive ability and skills, including verbal memory and ability, spatial skills, nonverbal reasoning, and analytical skills.

In addition to the evidence that the arts improve cognitive ability, companies are also increasingly looking to hire employees with arts-related skills. A study called *Ready to Innovate* found that companies increasingly want "workers who can brainstorm, problem-solve, collaborate creatively and contribute/communicate new ideas" (Tarnoff 2010). While there is clearly a significant benefit in bringing the arts and sciences together, doing so is difficult. This is where design comes in. Buchanan (1992, 6) suggested that new "integrative disciplines" are needed to bridge the gap between the arts and sciences. More specifically, he proposed that the disciplines of design and design thinking are ideally suited to identifying the connections between and integrating the knowledge from different disciplines to solve contemporary problems. He declared that establishing design thinking as a new liberal art could dispel "the modality of *impossibility*" (20, emphasis in the original), which includes:

> ... the impossibility of rigid boundaries between industrial design, engineering, and marketing. It points toward the impossibility of relying on any one of the sciences (natural, social, or humanistic) for adequate solutions to what are the inherently *wicked problems* of design thinking. Finally, it points toward something that is often forgotten, that what many people call "impossible" may actually only be a limitation of imagination that can be overcome by better design thinking. (Buchanan 1992, 20-21, emphasis in the original)

Ultimately, Buchanan argued that the establishment of design thinking as a new liberal art would not only change the way we perceive these impossibilities, it would also allow designers to function as intermediaries between disciplines and facilitate communication with those from other disciplines (14).

Philosophical theories on aesthetics

This section provides an overview of the key philosophies that have informed this research. It is not, by any means, intended to be a complete history of aesthetics or philosophy[5]. In "Analytic philosophy and pragmatism", the contrast between analytic philosophy and pragmatism is discussed. The information in this subsection is primarily drawn from Shusterman (1992), Stecker and Gracyk (2010), and *The Stanford Encyclopedia of Philosophy* (found online). The selected sources adequately fulfil their function here, but have their limitations and faults. Shusterman is a proponent of pragmatist aesthetics and an ardent supporter of John Dewey. Stecker and Gracyk provide a contemporary perspective on philosophy that is more relevant to the present time. *The Stanford Encyclopedia of Philosophy* was selected as it adequately informs on the various philosophical topics, although admittedly it presents only one version of the history of philosophy. This is seen as sufficient since arguing for or against particular philosophical theories is not the aim of this thesis. "Experience and aesthetic experience" examines the terms 'experience' and 'aesthetic experience' in detail, and discusses why all experiences should be considered aesthetic experiences. In "Internalism and externalism", a basic explanation of both internalist and externalist theories is provided alongside a brief discussion of the debate surrounding these two theories.

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[5] For those so inclined, here are some recommendations for further readings on the history of aesthetics. Duncan (2000) provided a number of "good anthologies" on the history of aesthetics published in the 1960s, noting that *What is Art: Aesthetics Theory from Plato to Tolstoy* was probably the "best of them". Duncan also listed two "competent, but somewhat modest" examples from the 1990s: *Aesthetics, Classic Readings from the Western Tradition* by Dabney Townsend and *Aesthetics, the Classic Readings*, edited by David E. Cooper. The following three, more recent, works should adequately supplement the period from 2000 to the present: *Aesthetics: A Comprehensive Anthology*, edited by Steven Cahn and Aaron Meskin (Wiley-Blackwell, 2007), *A History of Modern Aesthetics* by Paul Guyer (Cambridge University Press, 2014), and *Aesthetics Today*, edited by Robert Stecker and Ted Gracyk (2010). Further inquiry into the details of the history of aesthetics should be well-served by these titles.

Analytic philosophy and pragmatism

The aforementioned separation of science from art was mirrored in philosophy. This was reflected in the form of two opposing perspectives: analytic philosophy and pragmatism. These two perspectives were more or less the basis for contemporary twentieth-century Anglo-American views of aesthetics (Shusterman 1992, 3). Analytic philosophy primarily influenced mainstream views regarding aesthetics in Anglo-American society in the 1950s. This was due to "an analytic revolution in English-speaking aesthetics" at the time. Pragmatism, along with other earlier aesthetic theories, were simultaneously "considered to be too speculative and unclear". (Leddy 2015) However, from the 1970s onwards, a renewed interest in pragmatism finally saw it acknowledged as a major contributor to philosophy (Hookway 2016).

Analytic philosophy

Analytic philosophy was modelled on scientific philosophy. Analytic philosophers believed the presence of beauty and the presence of natural qualities were mutually exclusive, and were "sharply opposed to naturalizing art and aesthetic value" (Shusterman 1992, 7). They took this approach from Immanuel Kant, who proposed that aesthetics is dependent on "not what gratifies in sensation but merely what pleases by form". In other words, objects must appeal to the intellect to be aesthetic (and having an appreciation of such objects is indicative of good taste). Conversely, objects that appeal to the senses instead of the intellect—that produce an instinctive, natural response such as "emotion and sensual pleasure"– are not considered to be aesthetic. (Shusterman 1992, 8)

Since analytic philosophy draws from Kant, it is useful here to examine Kant's four features of the aesthetic judgements of beauty: subjectivity; universality; disinterest; and engages the senses, imagination, and intellect. For an aesthetic judgement to be subjective, Kant proposed that it had to be "based on a felt response of pleasure rather than the application of a rule or concept" (Stecker and Gracyk 2010, 35). The idea behind subjectivity is that aesthetic judgements do not result from cognitive activity such as applying rules (e.g. if the object is round and white, it is beautiful) but rather from an emotional reaction (e.g. feelings of pleasure) to the beauty of the object (and not an emotional response to the object itself) (Ginsborg 2014). With regard to universality, the aesthetic judgement is made with the belief that others in the same position would also make a similar judgement. In the words of Kant, "He judges not merely for himself, but for everyone" (Stecker and Gracyk 2010, 40). Essentially, this means that the object's beauty is not determined by a single individual's aesthetic judgement, but by the existence of a concordance between the aesthetic judgements of all individuals in response to the object (Ginsborg 2014).

As for disinterest, the aesthetic judgement must be independent of any influence "be it material, cognitive, or moral", even "the very existence of the object" itself. Instead, the judgement of an object should focus on "the experience it delivers in the contemplation of it." (Stecker and Gracyk 2010, 35) This means that an individual's aesthetic judgement of the object is not the result of a pre-existing desire for the object, nor the result of desire generated from coming into contact with the object (e.g. viewing, experiencing, or otherwise) (Ginsborg 2014). With regard to the last feature, to engage the senses, imagination, and intellect, Kant suggested that "order and regularity" should be eschewed for "that with which imagination can play in an unstudied and purposive manner" (Stecker and Gracyk 2010, 44). Put another way, the object's ability to generate "free play" or "free harmony" between an individual's imagination and understanding, where the individual's imagination works in harmony with the individual's understanding but is not constrained by it (Ginsborg 2014).

Pragmatism

While analytic philosophy proposed that aesthetics be determined via the ability of an object to provoke intellectual admiration and contemplation (as opposed to the evocation of an emotional response), pragmatism sought to establish that the presence of aesthetics should not be limited solely to objects (specifically, works of art). Instead, pragmatists thought that aesthetics and aesthetic judgement should be applied more broadly, to include all ordinary everyday experiences. John Dewey, a key proponent of pragmatism, essentially considered all experiences—both the artistic and the ordinary—to be aesthetic. This pragmatist approach is arguably more holistic, as can be seen from the following description:

> The business of aesthetics is to restore the continuity between the refined experiences that are works of art and the experiences of everyday life. We must, in short, turn away from artistic products to ordinary experience. (Leddy 2015)

The subsequent section "Experience and aesthetic experience" examines both these terms in more detail and, in so doing, explain why all experiences should be considered aesthetic experiences.

Experience and aesthetic experience

Dewey and other pragmatists all argued against the traditional view of experience held at the time, each proposing a slightly different interpretation. William James (1842-1910), for instance, stated:

> … the relations between things, conjunctive as well as disjunctive, are just as much matters of direct experience, neither more nor less so, than the things themselves … the parts of experience are held together from next to next by relations that are themselves parts of experience.

In other words, experience is not simply the receiving of sensory information (or sense data) as we interact with the external world—it also encompasses the internal process we engage in to make connections between these disparate pieces of sensory information. Charles Sanders Peirce (1839-1914) also made a similar proposition in the context of perception, noting that our perceptual experience of the external world is continuous and inferential; we perceive the world around us, and make connections between what we perceive. (Hookway 2016)

Dewey's view was an extension of these. He proposed that experiences consist of the combined interactions between feeling (emotion), thinking (cognition), doing (action or creation), undergoing (perception), and understanding (interpretation). This is somewhat supported by Leddy's observations:

> Dewey believed it unfortunate that no term covers the act of production and the act of appreciation combined as one thing. … Once we see conscious experience as "doing and undergoing" we can see the connection between the productive and appreciative aspects of art. "Art" denotes the process of making something out of physical material that can be perceived by one of the senses. "Aesthetic" refers to experience as both appreciative and perceptive. It is the side of the consumer. And yet, production and consumption should not be seen as separate.

Essentially, Dewey saw experience as—in the words of Hookway (2016)—"a process through which we interact with our surroundings, obtaining information that helps us to meet our needs" and that we cannot separate the sensory information we receive from interacting with the external world from the process we use to interpret it. Leddy's (2016) discussion of Dewey's aesthetics offers further insight and a deeper understanding of Dewey's perspective on experience. From this, two concepts are worth mentioning here.

The first concept is that experiences are characterised by connection, unity, and flow. For a group of individual events to be an experience, they must be occur in a series (connection), they must have discernible relationships (flow), and they must have unity in terms of their aesthetic qualities (unity). At the same time, an experience is the result of achieving balance between doing something (as part of the experience) and undergoing the experience itself, culminating in a result that feels harmonious to the individual engaged in the experience. (Leddy 2016)

The second concept is that "experience should be understood in terms of the conditions of life" (Leddy 2016). Experience is not what happens in an environment, but is what occurs when we interact with an environment or with others within an environment. Garrison succinctly explained it thus:

> Experience for Dewey was simply what happened when human beings *actively participated in transactions* with other natural experiences…. Everything that exists in nature and participates in natural interactions, everything carries on transactions with everything else—these interactions are *what* human organisms experience. Experience, for Dewey, is simply *how* the human organism interacts with its environment. (Garrison 1994, 9, emphasis in the original)

This explanation of experience is particularly helpful when extended to include aesthetic experience, which Dewey believed should not be differentiated from ordinary experience.

More recently, Laurel (1991) and McCarthy and Wright (2004) built on Dewey's view of experience, alluding that engagement in experiences involves the mind, emotions and the senses. Comparing the experience of theatre and computers, Laurel wrote, "both have the capacity to represent actions and situations … in ways that invite us to extend our minds, feelings, and sensations" (32). Separately, McCarthy and Wright adopted the perspective that experience is "a process of sense making" (18)—it is the result of individuals acting upon that which surrounds them (objects, spaces, people) and vice versa. Consequently, they proposed that "pragmatism tells us that our experiences do not come to us ready made … we bring as much to the experience as the filmmaker or designer puts into it" (21). They also explained that, from a pragmatist perspective, experience "is more inclusive than knowledge because it tries to encapsulate a person's full relationship—sensory, emotional, and intellectual—with his or her physical and social environment" (54).

McCarthy and Wright's interpretation of experience is also influenced by Bakhtin's views on experience. Like Bakhtin, they recognised the significance of the individual's role in experience—in other words, when an individual engages in an experience, he or she experiences it in a way that is unique and distinct from that of other individuals who engage in the same experience (56-57). McCarthy and Wright's more expansive explanation of experience is slightly more useful than Garrison's and Laurel's as it makes specific references to people's actions—which are performed using their body—as well as how they engage with their physical and social environment. Thus, expanding on the earlier statement above, engagement in experiences involves the mind, the body, emotions, and the senses, as well as engaging physically and socially with objects, places, and other people.

This last interpretation of experience bears close resemblance to Jensen's (2013, 196-197) detailed—but somewhat unwieldy—definition of experience:

> Experiences (understood as particular instances of or the processes or facts of personally observing, encountering or undergoing something) are sensory-based effects that humans get in interaction with products/objects, services, events, processes, other people, surroundings and so on, which are reflected in the form of emotional impressions and/or meaningful experiences (understood as the knowledge or practical wisdom gained from what one has observed, encountered or undergone). Experiences are a consequence of the experiencing individual's internal state (for example, needs, wishes, motivations, personality traits, emotions, convictions, values, culture, knowledge, skills, expectations, mood/spirits/sentiment and so on), characteristics of the product/object, service and so on (for example, functionality/ utility, usability, accessibility, design, brand and so on) and the context in which the interaction takes place (for example, environment/physical context, social context, cultural context, technological context, temporal context, organizational context, task-related context and so on).

Figure 1 shows Jensen's graphical presentation of the above:

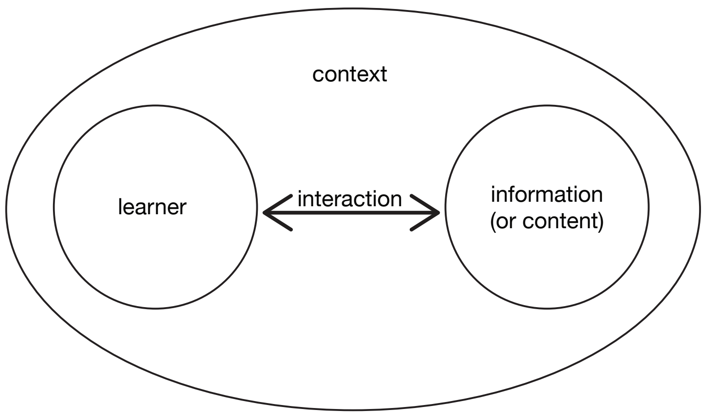

Figure 1: Model of experience based on the interaction between user and product in context (reproduced from Jensen 2013, 197)

Another significant point is that the earlier perspectives (e.g. Dewey, James, Peirce) on experience focused primarily on the individual's actual direct experience. Iseminger (2003) described this as an epistemic concept of experience, or the "direct or non-inferential knowledge" of actually having the experience. He also described another concept of experience—a phenomenological one—that refers to an indirect conceptual understanding of "what it is like" to have the experience. (100) In other words, the epistemic concept of experience refers to our own personal knowledge of having a particular experience; at the same time, our interpretation of another person's experience can only ever be phenomenological, since we cannot know exactly what it is like to experience something from that person's point of view.

Following on from his categorisation of experience as being either phenomenological or epistemic, Iseminger (2003) categorised and described aesthetic experience in a similar fashion:

> A phenomenological concept of aesthetic experience, accordingly, is a conception of what it is like to have an aesthetic experience. … An epistemic conception of aesthetic experience, on the other hand, is a conception of a non-inferential way of coming to know something … which deserves to be thought of as aesthetic. (100)

Iseminger also examined in detail Monroe Beardsley's phenomenological perspective of aesthetic experience and George Dickie's critique of it. For the purpose of discussion, Iseminger's quotation of Beardley's explanation of aesthetic experience is presented here:

> A person is having an aesthetic experience during a particular stretch of time if and only if the greater part of his mental activity during that time is united and made pleasurable by being tied to the form and qualities of a sensuously presented or imaginatively intended object on which his primary attention in [sic] concentrated. (Beardsley 1969, quoted in Iseminger 2003, 102)

The significance of this description is that it features unity as a key property of aesthetic experience, which parallels Dewey's views on experience. At the same time, it downplays other properties of aesthetic experience previously identified by Beardsley—intensity and complexity—in favour of pleasure[6] (which is derived from sensory experience and imagination). Iseminger saw this as a shift toward "the border between phenomenological and the epistemic notions of experience". He explained this in relation to one aspect of Beardsley and Dickie's debate over aesthetic experience, which centred on the concept of unity in relation to affects (which Dickie uses to refer to feelings, emotions, expectations, and satisfactions) and thoughts[7].

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6 Later, Beardsley (1982) rejected this earlier proposition—that pleasure is a key property of aesthetic experience—as being too reductionistic.

7 Their exchanges on aesthetic experience appear to function on the lines of clarifying their thinking and

Dickie declared that an experience did not have to have unity in affects to be considered an aesthetic experience, while Beardsley explained that experiences did not need to include affects in order to be considered aesthetic experiences, and they might be contain unity in relation to thoughts. (Iseminger 2003)

Another important proposition made in Beardsley (1982) is that instead of applying the term 'aesthetic experience' to a limited number of special experiences, "a broader concept of the aesthetic in experience" should be applied to all experiences (quoted in Iseminger 2003, 103). Iseminger described this later view of aesthetic experience as being "something like the Deweyan idea of *an* aesthetic experience, involving an overarching unity in some stretch of one's mental life". (Iseminger 2003, 103, emphasis in the original) Similarly, McCarthy and Wright (2004) noted that both Dewey and Bakhtin saw aesthetic experience as "the key to understanding how rich all experience can be" and that "it should be seen as continuous with ordinary experience" (57). At the same time, however, Dewey saw experiences as being distinct from aesthetic experiences. He recognised that although experiences that are "mostly intellectual or practical in nature" (e.g. philosophical and scientific experiences) can possess aesthetic qualities, this does not necessarily mean they are aesthetic experiences[8]. (Leddy 2016)

Put another way, an aesthetic experience "involves a drama in which action, feeling, and meaning are one" (Leddy 2015). Aesthetic experiences can only be achieved by balancing the interactions between action, feeling, and meaning, in order to produce changes that are dynamic but cumulative, so they lead to resolution or fulfilment. Consequently, the individual perceives an aesthetic experience because he or she is interested in the entire series of connected events, including those leading up to, during, and after the experience. (Leddy 2016)

Contemporary philosophy has attempted to reconcile this apparent contradiction. Having shifted away from the analytic philosophy that dominated mainstream Anglo-American views of aesthetics in the twentieth century, Stecker and Gracyk recently observed that contemporary philosophers "have become increasingly interested in the aesthetics of ordinary things" (2010, 34). This has resulted in the view that the concept of aesthetic experience should not be limited only to nature and art, but be applied to "the everyday, math, and science" as well; they

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understanding of the term 'aesthetic experience'.

[8] "Thinking has its own aesthetic quality. It differs from art only in that its material consists of abstract symbols rather than qualities. The experience of thinking satisfies us emotionally because it is internally integrated, and yet no intellectual activity is integrated in this way unless it has aesthetic quality. Thus, for Dewey, there is no clear separation between the aesthetic and the intellectual." (Leddy 2016)

declared the experience of solving a difficult math problem with "an elegant proof" could be considered an aesthetic experience. This line of thinking led them to two conclusions: that all human experiences are also aesthetic experiences, and that the notion of aesthetic experience is so vague that it has resulted in "the conflation of different conception [sic] of … experiences". (Stecker and Gracyk 2010, 34) Taking into consideration Garrison's explanation of Dewey's view of experience, if experience "is simply *how* the human organism interacts with its environment", then it is not difficult to see why all human experiences is should be considered aesthetic experiences.

All of the above perspectives provide valuable contributions toward the understanding of experience and aesthetic experience. Importantly, they recognise that experiences are an integral part of human existence and a person's existence can thus be said to be the sum of the experiences accumulated throughout his or her life, with these experiences occurring as a result of both being in the world and interacting with it.

Internalism and externalism

In *The Stanford Encyclopedia of Philosophy*, Shelley (2013) differentiated between phenomenological and epistemic aesthetic experience by referring to them as internalist and externalist respectively. Internalist theories are described as those that "appeal to features internal to experience, typically to phenomenological features", while externalist theories "appeal to features external to the experience, typically to features of the object experienced". Dewey was a proponent of an internalist approach. Beardsley started as a proponent of an internalist approach and later switched to an externalist approach. Beardsley's internalist theory was contained in *Aesthetics* (1958), in which he suggested that all aesthetic experiences had the following features: focus, intensity, and unity (which was further divided into coherence and completeness). As mentioned earlier, this theory—essentially a phenomenology of aesthetic experience—was criticised by Dickie for its failure to "distinguish between the features we experience aesthetic objects as having and the features aesthetic experiences themselves have". The debate between Beardsley and Dickie eventually culminated in the development of an externalist theory—found in Beardsley's 1982 essay "The Aesthetic Point of View"—and Beardsley's eventual conversion to an externalist approach. Thus, Beardsley—and many others after him—came to support an externalist theory, which views an aesthetic experience simply as "an experience having aesthetic content, i.e., an experience of an object as having the aesthetic features that it has". (Shelley 2013)

A more recent—but slightly different—interpretation of internalism and externalism was provided by Baofu (2009). Baofu saw the internalist approach as relating to the inherent qualities of the work, with the externalist approach relating to the external factors that influence the work. Thus, the internalist approach occurs "from the perspective of the internal elements of the work itself" (e.g. the "harmony, melody, affects, texture, and rhythm in music"), and is more common in the field of aesthetics. The externalist, on the other hand, occurs "from the perspective of its external factors". It takes into account "authorial intentionality, cultural influence, class struggle, gender estrangement, moral purification, and family background", and is typically adopted in art criticism.[9] (Baofu 2009, 6-7)

Internalism and externalism were also discussed in Lavazza and Manzotti's (2011) paper on how neuroscience can be used together with aesthetics and art to gain a better understanding of aesthetic experience by studying the mind (501). In neuroscience, as in aesthetics, internalism and externalism are considered to be "conflicting views" (507): internalism is based on "the idea that the mind is located inside the body" (508); externalism, on the other hand, "suggests that the mind is physically embodied in processes external to the nervous system and possibly to the subject's body" (509). Scientist Jan Koenderink described externalism as being derived "from the interaction of the embodied brain and the world" (Lavazza and Manzotti 2011, 509).

Taking the neuroscientific concept of internalism and putting it into the context of aesthetic experience, Lavazza and Manzotti (2011) explained that if internalism were true, then perhaps aesthetic experience could be proven to "be the result of some special properties instantiated by specific neural processes inside the brain" and the aesthetic value of an artwork could be established through its "ability to trigger the right kind of neural response" (508). However, this has yet to be proven. Still, in the future, the relatively new discipline of neuroesthetics—a hybrid of neuroscience and aesthetics which assumes that "our experience of the world, including our aesthetic experience, is rooted in brain activity"—might provide further

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[9] Baofu (2009) also cited a third approach to the internalist-externalist debate—to mix the two. He called this a pluralist approach, which he declared "most relevant in this day and age of postmodernism in the arts" (7). At the same time, he criticised it for being guilty of "reverse-reductionism in embracing the 'anything-goes' mentality" where "all ways of doing art and literature … are fine, with no one being more superior than the other" (p. 158). Baofu then proposed a fourth approach—his own—to address the issues with the first three approaches. He called it "the transformative theory of aesthetic experience" (7). This approach "adopts a multi-dimensional perspective of aesthetic analysis" (159), a summary of which can be found in his book *The Future of Aesthetic Experience* (Baofu 2009, 170-171, Table 6.3). This thesis does not incorporate or adopt Baofu's transformative theory, but, like him, it embraces multi-dimensionality with the view that it is necessary to be wary of reductionism and reverse-reductionism with respect to aesthetic experience.

insight through its use of neuroscientific methods to "study how the brain responds to art, seeking neural correlates of experiences" (506). At present, however, neuroscience's inability "to provide a final theory of conscious experience" (508) and "a lack of both a convincing empirical evidence and sound theoretical framework" (509) has seen internalism abandoned in favour of externalism.

Aesthetics in instructional design

This section is an excerpt from the journal article "Aesthetics in Instructional Design: Does Interactivity Count?" in The International Journal of Visual Design in 2015. *This article has also been presented as a paper in the 8th International Conference on Design Principles and Practices, Vancouver, Canada in 2014. Portions of this article can also be found in the sections "Learning and education" and "Learning and technology".*

It is no secret that aesthetics has been somewhat neglected in instructional design. The military origins of instructional design, with its early reliance on behaviourist principles and theories, paved the way for a reliance on scientific and model-based approaches that ignored the aesthetic dimension (Brown et al. 2013). Kanuka (2006) described them as "linear and cyclic, systematic and prescriptive" (p. 4). More recently, researchers observed that most models are "based on the principles of analysis, design, development, implementation, and evaluation (ADDIE)" and "any reference or integration of aesthetics" was completely absent (Brown et al. 2013, 9). Others noted that existing instructional design research is "primarily concerned with designing for and measuring performance improvement, implementing systematic instructional design procedures, and developing media for instructional purposes" (Miller, Veletsianos and Hooper 2006).

There is evidence that changes are occurring in instructional design, albeit slowly. Current growth in research on aesthetic dimensions is minimal. With the exception of a few recent papers (Brown et al. 2013; David and Glore 2010; Miller, Veletsianos and Hooper 2006; Parrish 2009), there is little other research on aesthetics in instructional design, and even fewer involving aesthetics in instructional design for K-12 education.

Conversely, there is increasing interest in aesthetics within human-computer related fields of research. In 2011, an analysis of empirical research in user experience found that aesthetics "is one of the most frequently researched dimensions in this field" (Bargas-Avila and Hornbæk 2011, cited in Tuch, Presslaber, et al. 2012, 1596). Aesthetics also makes a regular appearance in recent studies on website design and human-computer interaction. These studies looked at aesthetics and attractiveness (Hartmann, Sutcliffe and De Angeli 2007), first impressions (Lindgaard et al. 2006; Reinecke et al. 2013; Tuch, Roth, et al. 2012), aesthetics and usability (Hassenzahl 2004; Lee and Koubek 2010; Sonderegger and Sauer 2010; Tractinsky, Katz and Ikar 2000; Tuch, Roth, et al. 2012), perceived aesthetics value (Van Schaik and Ling 2009), dimensions of visual aesthetics (Lavie and Tractinsky 2004), eLearning and aesthetics (Duh, Bedrac and Krašna 2012), and more recently, visual complexity in websites (Wang 2013).

Instructional design in K-12 education has started to embrace the use of technology but this seems to merely involve the digitisation of existing classroom and learning systems (e.g. lectures, tests, etc.) (Rosen 2010, 59). With research showing mixed success of digital technology use in classrooms (Blackwell et al. 2013; Ifenthaler and Schweinbenz 2013) and no conclusive evidence that learning in a digital environment is more beneficial, it seems many educators are playing it safe and choosing to stick with what they know. Still, the success of autodidactic schemes such as Sugata Mitra's Hole in the Wall (HIW) experiment and the distribution of tablets to children in remote Ethiopian villages by the One Laptop Per Child organisation demonstrates that "real disruption can only happen if we're able to unbundle education outside of old categories like lectures, tests and essays; and that 'education' itself demands rethinking" (Chatfield 2014).

Maybe instructional design demands rethinking too. Just as a change from print to digital without an accompanying change in the education paradigm fails to maximise the potential of digital technology, making changes in instructional design without first changing the aesthetics paradigm could fail to maximise the quality of the learning experience. Furthermore, with contradictory studies that both endorse and condemn digital devices as learning tools (Blackwell et al. 2013), it is no wonder many K-12 schools are unwilling to make the technological leap.

Technology and aesthetics

In this thesis, the term 'technology' generally refers to digital technologies such as computers, smartphones, tablets, and other devices. Research into these forms of technology typically focuses on their development and use. One such area of research is human-computer interaction (HCI), which originated in computer science but has now "expanded to encompass visualization [sic], information systems, collaborative systems, the system development process, and many areas of design" (Caroll 2016). Today HCI draws on and integrates the many different perspectives of aesthetics found in other disciplines. Thus, despite a lack of interest in aesthetics in early HCI research, from the mid-1990s aesthetics has consistently—and increasingly—been the focus of studies in HCI, including website design (Tractinsky 2016).

Although there is now an abundance of research on aesthetics in HCI (and its related disciplines) available, much of this research has primarily been focused on visual aesthetics, where aesthetics is viewed as being primarily about appearance. However, some researchers in interaction design (a subset of HCI) approached aesthetics using Dewey's pragmatism. In addition, a broader view of aesthetics within interaction design has emerged, which can generally be described as focus on the aesthetics of interaction. These three main approaches are examined separately below.

Visual aesthetics and aesthetics as appearance

The investigation into visual aesthetics in HCI centred on the chapter "Visual aesthetics" in the Interaction Design Foundation's *Encyclopedia of Human-Computer Interaction* by Noam Tractinsky (2016) and the commentary that accompanied this chapter. The chapter itself provided a detailed and succinct overview of the key contributions to visual aesthetics research in the field of HCI, while the commentary that followed provided additional perspectives on visual aesthetics in HCI from prominent researchers such as Jeffrey Bardzell, Gitte Lindgaard, Marc Hassenzahl, Dianne Cyr, Alistair Sutcliffe, Jinwoo Kim, and Masaaki Kurosu. The most important and relevant information from these is summarised and discussed here.

In "Visual aesthetics" Tractinsky examined visual aesthetics from three different perspectives: design, psychological, and practical. He also presented the key contributors to aesthetic research in HCI, including their theories and research. His interpretation of aesthetics is conventional—he used "aesthetics" solely to describe objects that are beautiful or visually pleasing (1138) and referred to the Merriam-Webster's Collegiate Dictionary for a sample definition of aesthetics: "a pleasing appearance or effect: Beauty". At the same time, he highlighted the existing bias in visual aesthetics research, noting that they focused largely on the visual appeal of designed objects, rather than on "the effects of their ugly and displeasing counterparts" (1139). He also observed that research into users' aesthetic judgements of designed objects centred on how they were perceived by users, rather than on the aesthetic qualities that were inherent in these objects, and that these judgements resulted from both "quick, visceral reactions" and "very long, contemplative evaluations" (1139).

Examining visual aesthetics in HCI from a design perspective, Tractinsky referred to Vitrivius' three core principles: *firmitas* (strength and durability), *utilitas* (usefulness and suitability), and *venustas* (beauty) (1141). He noted that the early computing community focused primarily on *firmitas*, but only began to value *utilitas* because of the work and research on usability done in HCI. However, *venustas* was viewed with apprehension[10] until recently, because contemporary research[11] repeatedly shows a positive correlation between aesthetics and usability. (1141-1145) Tractinsky went on to describe how usability and aesthetics can overlap—Lavie and Tractinsky (2004) found that usability is highly correlated with what they referred to as "classical" aesthetics (where aesthetics is used to produce order and generally involve the use of Gestalt principles), and only moderately correlated with "expressive" aesthetics (where aesthetics is used in an original and creative way) (1146).

From a psychological perspective, Tractinsky argued that visual aesthetics is important

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[10] Tractinsky (2016) observed, "HCI and usability experts used to warn against putting too much emphasis on aesthetics (e.g., Norman, 1988; Nielsen, 1993)".

[11] Tractinsky (2016) cited Tractinsky et al. (2000), Lavie and Tractinsky (2004), Cawthon and Moere (2007), Sonderegger and Sauer (2010) as some examples.

because it “positively influences both emotional and cognitive processes”. More specifically, he proposed that aesthetics contributes “to pleasure and well-being”, is “a basic human need”, and serves as “an extension of the Self”. Furthermore, even though we form impressions of aesthetic stimuli very quickly—within 300 to 600 milliseconds (Höfel and Jacobsen 2007, cited in Tractinsky 2016)—we nonetheless use these impressions to inform our attitudes about an object’s hidden characteristics based on its visual aesthetics. Thus, changing the visual aesthetics of an object can change our attitudes towards it. (1146-1153) Finally, Tractinsky declared that recognising the importance of visual aesthetics is simply a matter of practicality. This is argued in two ways—first, that aesthetics can be used as “a differentiating factor”, and second, that it would be unwise to ignore aesthetics due to the pervasiveness of its use in technology and society at large. (1153)

The subsequent review of research on visual aesthetics in HCI was categorised into the following four main categories:

» The variables that influence aesthetic judgements and lead people to engage in aesthetic judgements;
» The aesthetic judgements and the psychological processes involved in these;
» The consequences of aesthetic judgements; and
» The factors that influence (1) and (3) above.

The first category provided an overview of research seeking to identify the variables that determine whether a designed object possessed visual aesthetics (i.e. whether it was beautiful or visually pleasing). Tractinsky observed that it was difficult to establish a universal set of guidelines for visual aesthetics as the requirements would vary based on application, product, and context. (1158-1163) The second category looked at how people perceive and evaluate visual aesthetics. This most influential piece of research in this category is arguably Norman’s three levels of processing—visceral, behavioural, and reflective (see page 58). These are based on two notions: (1) that visual aesthetics can produce cognitive and emotional responses, and (2) that cognition and emotion both play a role in the generation of aesthetic judgements. The bulk of the other research mentioned in this category examined how and when aesthetic judgements are formed. (1163-1165)

The third category examined whether the use of visual aesthetics produced particular outcomes and how this was accomplished. These outcomes included behavioural (e.g. improved performance) and emotional (e.g. positive affect) responses to designed objects and users’ perceptions of the designed object (e.g. trustworthiness, brand personality). It also included research on how visual aesthetics affect "other perceived attributes of the product" (such as usability, satisfaction, and performance). (1165-1168) The fourth category focused on research that studied the factors that influenced aesthetic judgements and aesthetic preferences. These included the type of system used, context of use, cultural differences, as well as individual preferences. Collectively, the research in this category indicated that whether or not a designed objects needs to have visual aesthetics is largely dependent on its intended use. (1168-1170)

Tractinsky concluded the chapter with a review of the methodological issues in existing research and, more importantly, an overview of what he recommended as necessary future research. The future research recommendations are of particular relevance here and the significance of these recommendations is discussed in "Recommendations for further research" on page 311. The following is a shortlist of the recommendations proposed by Tractinsky, edited to include only those that are applicable in the context of this research:

» Research that addresses the significant differences between the aesthetic judgements of designers and users.
» Research that examines the relationship between emotion, cognition and aesthetics, or what Tractinsky described as the "interplay of emotional and cognitive factors … at the three levels of processing" (visceral, behavioural, and reflective).
» Research that investigates the "dynamic aspects of visual aesthetics" (e.g. the "perceived aesthetic dimensions of animations").

Commentary by the other researchers in the field of HCI follows the chapter, providing a range of alternative, yet valuable, perspectives on Tractinsky's work. The first commentary, by Jeffrey Bardzell, centred its criticism on Tractinsky's limited approach to both aesthetics and visual aesthetics, while at the same time acknowledging Tractinsky's intentional focus on "the empirical science of aesthetics". He declared that Tractinsky's decision to view 'visual aesthetics' as a combination of "two standard dictionary definitions … disengages with millennia of aesthetic thinking in philosophy, art history, literature, architecture, and film" to be problematic for several reasons. The most significant of these reasons, wrote Bardzell, is that the chapter actually presented visual aesthetics in a manner that goes beyond what he called "ordinary people's intuitive interpretation of the terms", which he observed to be "a philosophical infrastructure for an academic theory of aesthetics" instead.

Additionally, Bardzell also made a number of assertions, some of which closely align with those held in this research. These include:

» *The importance of aesthetic experience as a research theme in HCI and other interaction-based design*—Bardzell described aesthetic experience as "intellectually and emotionally rich and fulfilling, thus improving quality of everyday life" (1191) and observed that it is "a major topic in nearly all domains that identify themselves as 'aesthetic,' from recent analytic philosophy to the ancient Greeks, and from cognitive science to postmodern literary theory" (1213).

» *The need to consider the aesthetics of interaction and interactivity*—Bardzell noted that the proliferation of interactive technology has influenced "how people interact with themselves, each other, and the world" and this means that the aesthetics of interaction and interactivity should be seen as "imperative, rather than optional" (1192). He also suggested moving beyond the visual, stating, "it would seem that interactive, rather than visual, aesthetics would be the target"[12] (1201).

» *The need for an interdisciplinary approach to understanding aesthetics in relation to HCI and other interaction-based design*—specifically, Bardzell mentioned that aesthetics in HCI and design is guilty of "self-imposed exile from millennia of interdisciplinary aesthetic thinking" (1203) and that we should "accept the legitimacy of [Tractinsky's] aesthetic processing but to end its self-imposed exile from the rest of aesthetics." (1204)

» *The suggestion that aesthetic experiences are how we learn about those around us*—Bardzell pointed out that a number of aesthetic theories posit that we primarily learn "what it is like to live in the distinctive way of someone else" through authentic and personal aesthetic experiences (1207).

» *The view that there is a relationship between interactivity, experience, and learning*—Bardzell observed that the medium-specific theories of Bolter and Gromala (2006), Löwgren (2006, 2009), and Lim et al. (2007) also suggested that interactive aesthetics are "holistic understandings, explorations of design qualities, and efforts to link together interaction attributes with experience and understanding as they are consciously present to us". (1211)

Bardzell's commentary was followed by that of Gitte Lindgaard. Lindgaard also offered a number of propositions that align with the views held in this research. These include:

» *The view that context is significant because it can dictate people's expectations of visual aesthetics*—In other words, the appropriateness of the visual aesthetics of a designed object (in this case, interactive technology-based objects such as websites, computer games, etc.) is dependent on the context. People's expectations of aesthetics (and content) are different in different contexts, and thus what is seen as appropriate in one context may not be appropriate in

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[12] This concern is also mentioned in Jinwoo Kim's commentary.

another. This is because a person who sees the same visual aesthetics attributes across separate experiences within the same context or genre (e.g. a number of different banking websites) will come to think of them as characteristic of that particular context and expect them to be present each time. (1223)

» *The idea that affect and cognition, along with existing models and paradigms within HCI, should be viewed holistically instead of as disparate concepts*—Lindgaard wrote that "it may be time for HCI researchers as well as product designers to consider the concepts of affect and cognition as an integrated whole, in addition to existing models and paradigms" (1222).

The commentaries by Marc Hassenzahl and Dianne Cyr both discussed visual aesthetics in relation to beauty. Hassenzahl declared that beauty is a social construct (1244). Thus, although we now know that our emotional response from "looking at" an object influences our judgement of its beauty, and this judgement in turn affects how we perceive the object's other attributes (e.g. "how practical or captivating an object is"), we are still unable to establish the rules for "how to make something beautiful" because our perceptions of beauty are constantly shifting (1240-1241). These perceptions of beauty are swayed by our levels of familiarity with the object (or experience), as well as our reliance on the opinions of recognised authorities (1242). Cyr reiterated Tractinsky's view of aesthetics as relating to pleasure derived from appearance. Like Tractinsky, she also acknowledged 'aesthetics' and 'beauty' are both lacking in clarity, and her commentary takes into consideration the impact of aesthetics and beauty on pleasure and emotion. However, the focus of the commentary is largely centred on the three areas that would benefit from further theory-based and data-driven research.

Alistair Sutcliffe's commentary also acknowledged difficulties in defining "just what constitutes an aesthetic design" (1255). He recognised that it is inadequate and problematic to consider only the visual aesthetics aspect of a user experience—"for example, is our reaction to an interactive animated character determined by its appearance (visual aesthetics), how it interacts or a combination of both?"—and pointed out that "visual aesthetic is but one component"[13] in "a complex interaction between several qualities", including interactivity and functionality. As such, it is pointless to try and determine what constitutes an aesthetic design because "not only is beauty in the eye of the beholder, it also changes over time" (1255-1256). Sutcliffe used the term 'user engagement' to collectively discuss both the visual aesthetics and interactive qualities of an object, noting that while visual aesthetics is influential in making first impressions,

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[13] Sutcliffe cited a number of publications in relation to this, including De Angeli et al. (2006), Hartman et al. (2007), Hartman et al. (2008), and Sutcliffe (2009).

its influence can be reduced when the object is in use—particularly where interactivity and functionality are more important. He also produced a model of user engagement to visualise the sequence of events during an experience.

In addition, Sutcliffe highlighted that although it is universally agreed that a user's judgement of products and experiences is dependent on context, the extent of its influence relative to that of general psychology is the subject of debate. He—along with Tractinsky—are aligned in their view that psychology is integral in explaining how users make judgements, stating that they both considered user judgement to be complex—it is influenced by multiple factors[14], and visual aesthetics (both classical and expressive) is but one of these. He described McCarthy and Wright as being in opposition to this, since they were of the view that "visual aesthetics is a pragmatic endeavour which can only be analysed in context and created through experience" and that all user experience can only be understood by examining the relationships (or 'dialogue') between the user, product, and context. (1258)

Pragmatism in interaction design

Dewey's pragmatism can be said to have led to a number of shifts in the understanding of interaction design (McCarthy and Wright 2004; Petersen et al. 2004). This was explored via the review of two main texts: Petersen et al. (2004) and McCarthy and Wright (2004). Petersen et al. (2004) wrote a paper advocating for a pragmatist approach to aesthetics in interaction design. Based on this approach, they proposed a concept of "Aesthetic Interaction" which "can be obtained when the human body, intellect and all the senses are used in relation to interactive systems" (269). In their view, aesthetic experience is derived from interaction that involves the mind, the body, and socio-cultural context. Thus, a user's experience of an interactive artifact is influenced not only by the aesthetic expression within the artifact, but also by the context in which the user experiences it. The context includes both the user's personal background and existing knowledge, as well as circumstances (e.g. spatial, temporal, social, etc.).

Separately, McCarthy and Wright's (2004) book *Technology as Experience* explored Dewey's pragmatist interpretation of aesthetic experience and the notion of technology as an aesthetic experience, with references to the disciplines of HCI, user experience design and interaction

[14] Sutcliffe stated, "Noam and I believe, the picture is more complex with components such as classic and expressive aesthetics, user engagement, service quality, etc., competing to compose the final impression of satisfaction, emotional reaction or preference" (1258).

design—all of which are key areas of interest in this research. The most significant aspect of their work is the acknowledgement that "interacting with technology involves us emotionally, intellectually, and sensually" (ix). They proposed that technology should be thought of as something we experience, rather than merely a tool we use to accomplish goals and tasks. Overall, their views on technology as experience were largely influenced by the ideas of John Dewey and Mikhail Bakhtin.

McCarthy and Wright highlighted Dewey's argument for the removal of the separation between aesthetic experience and ordinary experience, and built on this by proposing that aesthetic experience should include not just art and ordinary experience, but technology as well. In so doing, they declared that technology should be considered "deeply embedded in everyday experience, in ways that are aesthetic and ethical as well as functional" (ix). As for Bakhtin, they took into consideration his emphasis on the peculiar nature of experience as something that can be felt. They believed that in order to understand how people experience technology "we must understand the emotional response and the sensual quality of the interaction"—this they referred to as felt experience (13).

Technology as Experience contains nine chapters. Here, the focus will be on chapters 1, 2, 3, 4, 5, and 9, since these contain the main ideas that are of relevance[15]. The ideas in each of these chapters that are of most significance and importance to this research will be presented here. The first chapter, "Living with Technology", emphasises how important technology has become in the daily lives of those who live in contemporary society. McCarthy and Wright's organization of the first half of this chapter around Kuutti's history of the user, beginning with the reductionist[16] view of the user as "a cog in a rational machine" in the 1970s, followed by the behaviourist[17] approach that saw the user as "a source of error in the 1980s", to a more sociological and anthropological perspective of the user as "a social actor" in the 1990s, and

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[15] Chapters 6, 7, and 8 primarily contain case studies that illustrate the concepts covered in the earlier chapters.

[16] Reductionists (as defined in the Internet Encyclopedia of Philosophy) refer to those who seek to reduce a theory or phenomenon to its most basic (e.g. "a reductionist about biological entities like cells might take such entities to be reducible to collections of physico-chemical entities like atoms and molecules"). See http://www.iep.utm.edu/red-ism/ for a more detailed explanation.

[17] Behaviourism is considered to be a movement in both the fields of psychology and philosophy. Behaviourists (as defined in the Internet Encyclopedia of Philosophy) refer to those who focus on studying the external visible behaviours of a person (or, sometimes, an animal) as opposed to their internal thoughts and experiences. B. F. Skinner is perhaps the most well-known behaviourist, for his philosophy of radical behaviourism. There has been significant debate regarding this, see http://www.iep.utm.edu/behavior/ and https://plato.stanford.edu/entries/behaviorism/.

finally, to what was then the present day view of the user as a consumer[18] (6). This parallels the evolution of technology's role in our lives, particularly in the context of HCI. Technology has evolved from a tool that is used primarily to accomplish utilitarian tasks, to one that is now also used to facilitate communication and personal expression.

McCarthy and Wright noted that this evolution was not always embraced or understood in human-computer interaction (HCI) and related disciplines. Those working in these disciplines found it difficult to consider technology alongside experience, largely because they are more accustomed to dealing with usability and other similarly quantifiable aspects of technology, and experience was by comparison a much more nebulous concept. This preference for concepts and outcomes that are clear and measurable over those that are ambiguous and less well-defined echoes the dominance of the sciences over the arts described in the earlier parts of the section on "Aesthetics" in this research.

The points of primary importance to this research are outlined in the latter half of the first chapter. These relate directly to the six propositions presented by McCarthy and Wright (12–21), namely:

» The relationship between people and technology should be interpreted in terms of the emotional (or felt) aspects of the actions and interactions within experiences.
» Social-practice accounts of interactive technologies at work, at home, in education, and in leisure understate the emotional aspects of experiences.
» It is difficult to develop an account of the emotional aspects of our experiences with technology.
» The pragmatist philosophy of experience can help to clarify the qualities of the emotional and sensual aspects of the actions and interactions within experiences.
» Because pragmatism values the emotional-volitional and creative aspects of experience, the aesthetic must assume primary importance in order for us to understand how we experience technology.
» Exploring revisionary theories of pragmatism is particularly valuable for us to understand technology and design.

The second, third, fourth, and fifth chapters contain a detailed explanation of McCarthy and Wright's interpretation of technology as experience. The second chapter examines "the

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[18] It is worth noting that this may have evolved further since then, given that it has been thirteen years since the publication of McCarthy and Wright's book.

turn to practice" in HCI, which McCarthy and Wright described as an attempt to re-establish the connection between the experience of making and using technology and the actual technological artifacts themselves (26). They explained that the turn to practice is necessary because for the purposes of discussion it does not make sense to separate a technological artifact from the contexts in which it is used, since these contexts are needed to establish the artifact's desired purpose and its suitability for this purpose. Furthermore, these are likely to change depending on the context. McCarthy and Wright observed that there were a number of different approaches taken in relation to the turn to practice: rationalist, phenomenological, ethnographic, political, ethnomethodological. They proposed that each of these approaches be viewed both sequentially and cumulatively, where each succeeding approach is informed by and builds on its predecessor (23). At the same time, they also noted that all of these approaches lack the ability to articulate the extent of felt experience where technology is concerned (24).

The rationalist approach typically involves detached third-party observations and interpretations of technology, with a focus on explicit reasoning, objectivity, and measurable variables. McCarthy and Wright described rationalism as:

> discursive practices that promote the notion of separation of mind, mental processes, and ideas from any material manifestation or embeddedness; the inherent purposefulness and intentionality of action where action is seen as the execution of a well-formed plan; and reification of cognition or knowing above being and participating (24)

The rationalist approach also frequently saw "means as separable from ends" (25). The problem with this is that it resulted technology being perceived in an idealised form, instead of the more realistic, ordinary form in which it is used and experienced, thereby providing an incomplete view of technology because it does not take into account the actual lived experience with—and of—technology.

The phenomenological approach sees a shift away from the view that technology is a stand-alone entity at the centre of human life. Rather, it sees technology as "social and practical, situated in ordinary, everyday activity" (29). At the same time, technology is also seen as transformative in terms of "what we can do and what we can see" (Winograd and Flores 1986, quoted in McCarthy and Wright 2004, 29). Although the phenomenological approach shifted perceptions of the relationship between technology and humans—and in so doing revealing how pervasive rationalism was—it continued in the rationalist tradition of examining technology use from an outsider's perspective.

The ethnographic approach changed this. Since ethnography is concerned with understanding "practices, relationships, and cultures from the inside" (34), the ethnographic approach sought to view technology use from within a practice context (e.g. work, education, play, etc.). Because of this, the ethnographic approach is subjective and rejects "the possibility of neutral description". It focuses on observing and describing experiences from individual perspectives, and seeks to generate dialogue about the differences between these. The political approach is similar to the ethnographic approach but its focus is limited to the relationships between technology and work, while adopting a political perspective. It is largely concerned with the political implications of technology use in practice, including the impact of technology, the role of the user in the process of producing technology-related design, and the role of technology (for example, whether its role is to increase the efficiency and effectiveness of humans, or to enhance their skills).

The ethnomethodological approach seeks to address a key issue of the ethnographic approach: the inevitable bias resulting from the creation of categories and frameworks prior to commencing the ethnographic process. McCarthy and Wright noted that this is a significant problem because the use of a pre-established framework in ethnography can skew any observations and descriptions, thereby making a true primary ethnographic account impossible. Thus, the ethnomethodological approach first seeks to understand the work that is to be supported before determining what technology is appropriate and how it should be applied. This approach is more methodical and empirical than the ethnographic approach, as it requires the practices preceding the creation of categories and frameworks to be described prior to their creation. However, as McCarthy and Wright pointed out, it still relies on attempts at primary description—the possibility of which is debatable—and this inclination towards objectivity can limit its usefulness in hypothesising about the future.

Having reviewed the various approaches in the turn to practice, McCarthy and Wright then declared that the turn to practice has itself become an obstacle to understanding the relationship between technology and people. They attributed this to the tendency for many of these approaches "to simplify the individual by presenting an underdeveloped account of self, identity, and individual diversity" (43). Their concern is centred on the assumption that people's experiences with technology primarily occur within a social context, thereby resulting in a lack of consideration for experiences that occur individually. They declared that activity should not be separated from experience, that experience can simultaneously be both individual and social, and that experience should not be considered either purely subjective or purely objective.

In other words, it is necessary to consider these relationally, as Dewey and Bakhtin proposed. Following on from this, McCarthy and Wright explained that this is best served by taking into account "individual and felt experience, as something lived through", and this must be done explicitly so that discussions involving the turn to practice and technology adequately reflect their inherent complexity (48).

In the third chapter, McCarthy and Wright highlighted two reasons why discussions about experience can be confusing. First, we cannot separate ourselves from an experience to describe it from an outside perspective because experience is always present. Or, as they explained, "Standing back from the experience of walking the gorge to describe it to a friend is, of course, living the experience of describing not the experience being described." (50) Second, there is inconsistency in the way we use the term 'experience':

> We make distinctions between learning something and having a learning experience, as if learning something is not an experience. We separate what we have learned from education and from our own experience, as if we were not involved in our own education. We distinguish between relationships we have over the Internet and relationships that we experience directly. Again, who exactly was experiencing the Internet relationship? We can also make distinctions between doing something like reading and having the real experience.

McCarthy and Wright then turn to outlining Dewey and Bakhtin's various approaches to experience in order to set the groundwork for their own approach. They emphasise that this necessary in order to demonstrate "the vitality of a pragmatist approach to experience—the livedness and feltness of it, the ordinariness and enchantment, the organic rhythms and personal engagement" (52). Dewey, on one hand, was depicted as representative of pragmatism. He was described by McCarthy and Wright as observing that there was a disregard for ordinary everyday experience, which he believed to be erroneous. The following quote from McCarthy and Wright can be used to summarise Dewey's pragmatist view of experience:

> For pragmatists such as Dewey, experience is more personal than behavior [sic]; it involves an active self who not only engages in but also creatively shapes action. It is more inclusive than knowledge because it tries to encapsulate a person's full relationship—sensory, emotional, and intellectual—with his or her physical and social environment. And, embedded as it is in what people do in the world and what is done to them, it is more than feelings. If these reductions are rejected, experience can be seen as the irreducible totality of people acting, sensing, thinking, feeling, and making meaning in a setting, including their perception and sensation of their own actions. (54)

Bakhtin, on the other hand, was not identified as a pragmatist, although McCarthy and Wright observed and discussed that there were parallels between his thinking and that of pragmatists. Bakhtin was described as being interested in the relationship between art and lived experience, while at the same time focused on individuality and the uniqueness of individual experience (55-56). His line of thinking led him to place greater value on "unique, personal experiences", which he saw as integral to "meaningful engagement" (56).

Although Dewey and Bakhtin approached experience in different ways, McCarthy and Wright noted that both Dewey and Bakhtin saw aesthetic experience as important and believed that "it should be seen as continuous with ordinary experience" (57). As such, Dewey and Bakhtin's use of aesthetic experience was not limited to art; it also included everyday experiences. McCarthy and Wright used this as the basis for their own approach to aesthetic experience, which they described thus:

> In aesthetic experience, the lively integration of means and ends, meaning and movement, involving all our sensory and intellectual faculties is emotionally satisfying and fulfilling. Each act relates meaningfully to the total action and is felt by the experiencer to have a unity or a wholeness that is fulfilling. (58)

They went on to explain although all experiences can potentially be fulfilling, including those that involve technology, this is different for different people. Essentially, the difference in whether or not an experience is fulfilling "can best be characterized [sic] in terms of the potential the technology offers for engagement in what would be, for us, a meaningful experience" (69). In order to achieve this, McCarthy and Wright declared that "we have to be able to see potential in everything and be open to surprise at any time", and that we should adopt Bakhtin's view of "the world as an open, unfinalized [sic], and unfinalizable [sic] place where every person and thing is always a dynamic process of becoming, always open to the future" (69). This relates to Bakhtin's perception that individuals actively construct and are the authors of their own experiences, and therefore their experiences are unique to themselves[19].

To explain how individuals engage in the co-creation of experiences, McCarthy and Wright proposed and discussed the following four threads of experience in Chapter 4: sensual, emotional, compositional, and spatio-temporal. They explained that these four threads are

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[19] Bakhtin referred to "this uniqueness of vision as a person's 'excess of seeing,' which is defined by the ability each of us has to see things that others don't see" (McCarthy and Wright 2004, 74). This creates a paradox, because although we can see what other cannot, we need others to give us access to what we ourselves cannot see—"I can look at my own body, but I cannot see myself doing so"(74).

not "elements of experience" but simply provide a means of "talking about technology that heighten sensibility to people's experience of it" (79-80). The sensual thread relates to sensory engagement—"the concrete, palpable, visceral character of experience" (80). McCarthy and Wright emphasised that true sensory engagement is not compartmentalised; all the senses are felt as a whole, all at once, with the body and mind working in sync. True sensory engagement thus produces a deep absorption in the experience, where one becomes "completely attentive, engrossed, intensely concentrated, and immersed or lost in an activity" (82), such that one feels as though one is part of what is being experienced.

The emotional thread relates to the emotional response to experience, including its sensual aspects. McCarthy and Wright noted that emotion "does not exist separate from the person, the situation, or the feelings of the person toward the situation" (83). McCarthy and Wright saw the emotional and sensual threads as occurring simultaneously, despite writing about them as separate threads that appeared to "[influence] each other through feedback" (86). Their intention was to highlight the sensual thread's focus on the immediate meaning of what is felt by the senses, and the emotional thread's focus on deriving meaning based on the individually-held values, goals, and desires (87). This approach sees both the sensual and emotional threads as contributors to the "sense-making process" that constitutes experience, which in turn relates to the third thread: the compositional thread.

The compositional thread takes into account the "relationships between the parts and the whole of an experience" (87). It considers how experiences can be given value and made meaningful, so they become aesthetic experiences that are "satisfying, enlivening, and sometimes challenging" (88). This promotes deeper engagement with an experience and leads to a greater feeling of immersion. The intensity of the immersion in an experience can alter our sense of space and time. This is where the spatio-temporal thread comes in.

The spatio-temporal thread reflects McCarthy and Wright's view that "[all] experience has a spatio-temporal component" (91). They referred to several others who have recognised the importance of time and space to experience (Coyne 1999; Bakhtin) (91); not only does time and space affect how we sensually and emotionally respond to an experience, they also influence the context in which the experience occurs.

They concluded the chapter with the idea that an experience is adaptive and constantly changing. Instead of being seen as having a beginning and an ending[20], it should be seen as being connected "with its circumstances and history through a continuous interplay between past, present, and future, each shaping and renewing the others" (104). Thus, it is necessary to include notions of "connectedness and continuity" in relation to experience (104).

The fifth chapter begins by stating that "experience does not come to us ready made" (105). It explores the individual's role in making sense of experience, as both a co-creator of and an active participant in the experience. It also takes into account that the individual's existing sense of self influences their experiences and how they make sense of these experiences, and that their sense of self can change during and after experiences (sometimes as a result of these experiences). At the same time, it considers the relationship between the self and other, which is typical in pragmatism—"there is no self without the other," wrote McCarthy and Wright, noting separately that "becoming a self always happens in the context of dialogue with others" (106). All this is examined in this chapter in relation to technology.

McCarthy and Wright looked at experiences that involved the use of technology and its role in the way we make sense of these experiences. In this chapter, they referred to computers and mobile phone text messaging. They described how Turkle's (1995) book *Life on the Screen* "documents the increasingly important role that computers play in shaping this sense of who we are" (106), particularly in our interactions with other people. They also discussed Kasesniemi and Rautiainen (2002)'s research into Finnish teenagers' mobile phone use, focusing on the text messaging aspects. From these they observed that when we make use of technology together with other people, the resulting experiences we have affect how we make sense of the technology, our sense of self, and our relationships with both technology and other people (or on a broader level, the communities we live in). Following a discussion of Mead's[21] and Bakhtin's[22] views in relation to this, McCarthy and Wright concluded that they saw the process by which we construct and make sense of experiences—and as a result, our sense of self—as dialogical and creative.

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[20] McCarthy and Wright (2004, 104) observed that the different events analysed by Laurel (1991) tended to be "bounded by a beginning and end of an activity or event".

[21] Mead's perspective was largely focused on social activity, and McCarthy and Wright wrote that he "described self as emerging from living communally with other individuals, as an individually distinctive member of that community" (2004, 110).

[22] The dialogical perspective comes from Bakhtin, who thought that "self is created intersubjectively in dialogue with the particular, personal other" (McCarthy and Wright 2004, 112).

Additionally, McCarthy and Wright also highlighted Bruner's (1986) view that having an experience and the expression of that experience is dialogical. This means that not only does having an experience affect how we express it, the act of expressing the experience—be it through talking, writing, creating, or thinking about it—can in turn also change the experience. Using narratives as the basis for explanation and drawing primarily from Bruner (1986), they explained how narratives not only put "experiences into circulation" by giving them a physical form, they also infiltrate actual experiences when they are being experienced, and then heavily influence how we make and derive meaning from experiences later on. It is worth noting that although the discussion focused mainly on narratives, the aforementioned statements can be said to apply to other forms of expressing experiences as well. Essentially, this chapter points out that neither experiences nor those who experience them are simple or static. Instead, they are complex 'organisms' that are constantly engaged in a neverending cycle of participation and co-creation, of interacting and reacting.

The ninth and final chapter summarised the key concepts from the previous chapters. These include McCarthy and Wright's focus on felt life (or felt experience) in relation to technology as a foundation for their "aesthetic approach to seeing technology as experience" (2004, 184); their original intent to apply "an aesthetic-experiential lens on technology" (184); the notion of "the playfulness of experience", where McCarthy and Wright stated that they saw their work as "putting the playfulness, openness, and emotionality of experience at the center [sic] of our concerns" (188). The chapter concluded that dialogue must replace "hierarchical modes of thinking—scientific and philosophical for example—that make centering [sic] and marginalizing [sic] inevitable" (189) and that "[richer] models for human-computer interaction are required if we are to take account of experience and people making sense of it". They suggested that "a strong literary or art-related approach to HCI and CSCW[23]" (189) is necessary to achieve this, of which their aesthetic-experiential approach is one way of doing so.

Of particular relevance here is McCarthy and Wright's discussion regarding what their work means for design (193), since this research is situated in the field of design[24]. They explained how their work is an attempt to restore "the continuity between the aesthetic experiences of designing technology and living with it" in the same way Dewey sought to restore the

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[23] CSCW is an acronym that stands for computer-supported cooperative work (McCarthy and Wright 2004).

[24] It is worth noting, as McCarthy and Wright did (2004, 193), that they are not professional designers. This contrasts my own background as a professional graphic designer. Additionally, they appear to view design as "a predominantly scientific or mathematical practice" (195). This is different from my own experience and interpretation of design, which combines a logical, analytical approach with an art-related one.

continuity between aesthetic experience and ordinary experience (193). To restore this continuity, McCarthy and Wright recommended a dialogical approach that "[treats] each person interacting with technology as a source of creative potential" (196) because of the constant dialogue between technology and people in which they mutually affect each other in relation to their present and future potential. This dialogical approach essentially requires designers to view technology design as more than the design of objects, but as the design of an experience that is integrated with technology, one with numerous possibilities (196-197).

The aesthetics of interaction

Pragmatism was not the only basis for a holistic approach toward aesthetics in interaction design. In interaction design, there have been several researchers proposing that greater emphasis be placed on designing with the whole experience in mind. Dalsgaard and Hansen (2008), for example, suggested that experience is not solely determined by the interaction design. Rather, it is co-created by the user and subject to change with the user's context. As such, they proposed that aesthetic experience is influenced by the different roles users play, as operator, spectator, and performer.

Lim et al. (2007) also saw the necessity of considering the whole experience in interaction design. Their work took a more practical approach, seeking to create a language that could be used to describe what they referred to as "the *shape* of the interaction" (249), where the interaction sits between the user and the user's experience. They called this the interaction gestalt[25], which "is experienced by a user and evokes the user's subjective experience of the quality of the interaction" (240). The following interaction gestalt attributes were identified: connectivity, continuity, directness, movement, orderliness, pace, proximity, resolution, speed, state, and time-depth. Lim et al. saw these attributes as distinct from the qualities of user experience or "experience qualities", which they understood to be "connected to personal judgment such as fun, engaging, comfortable, pleasant, excited, and etc." (249).

In addition to the interaction gestalt, Lim et al. (2007) also provided a valuable overview of three main areas of research into the aesthetics of interaction: aesthetics and usability; aesthetics and experience; and Shusterman's concept of "somaesthetics". They observed that the research on aesthetics and usability tended to focus on the relationship between perceptions

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[25] Lim et al. (2007) described a gestalt as "a composition of qualities that 'creates a unified concept, configuration or pattern which is greater than the sum of its parts'" (239).

of aesthetics and perceptions of usability. Norman, for instance, proposed three levels relating to the perception of beauty: visceral (related to sensory perception); behavioural (action-based and related to use); and reflective (related to how people judge beauty on an intellectual level). Tractinsky, Katz and Ikar (2000) looked at usability and beauty, where they found beautiful artifacts were seen by users as more usable. Hassenzahl (2004) found no correlation between usability and beauty; he found perceptions of goodness (resulting from the combination of usability and hedonic qualities) to be more important. Zhang and Li (2005) looked at usability and affect, finding "strong relationships between affective qualities and usefulness, and between affective qualities and ease-of-use" (243).

As in the previous section "Pragmatism in interaction design", Lim et al. also observed that the research on aesthetics and experience was largely influenced by Dewey's pragmatism. Looking at Shusterman's concept of "somaesthetics", they noted that it was based on Dewey's pragmatism, but developed it further. Unlike pragmatism which centred "more on the environmental and total experiential level" of aesthetic experiences, somaesthetics also took into account the "interaction between human sensory faculties and materials" (244).

Other researchers also embraced a holistic approach after recognising the limits of focusing solely on usability and function (Overbeeke et al. 2002; Overbeeke and Wensveen 2003; Petersen, Hallnäs and Jacob 2008). Overbeeke et al. (2002) declared that it was no longer adequate to rely solely on addressing function and ease of use through the structural aspects of affordances[26]. Interaction design had to adopt a more holistic view of the user, by considering the following three areas of interaction: cognitive skills, perceptual-motor skills, and emotional skills[27]. They viewed emotion—enjoyment, in particular— as crucial to achieving a richer aesthetics of interaction. As such, they proposed that in order to improve users' experience of these products, the goal should be joy of use not just ease of use.

Overbeeke and Wensveen (2003) took this further, proposing:

> … the user is in search of a positive experience. Therefore the designer needs to create a context for experience, rather than merely a product. She offers the user a

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[26] 'Affordances' is a term adopted from perception-psychology (Gibson 1979, cited in Overbeeke et al. 2002, 9). It is based on the view that the relationships between perception and action, and between a person and his environment, are intertwined (Overbeeke et al. 2002, 9).

[27] In interaction design, the usability approach has paid substantial attention to cognitive skills. By contrast, perceptual-motor skills and emotional skills have been neglected, however this has gradually changed over time. (Overbeeke et al. 2002, 7-8)

> context in which he may enjoy a film, dinner, cleaning, playing, working … with all his senses. It is her task to make the product's function accessible to the user whilst allowing for interaction with the product in a beautiful way. Aesthetics of interaction is his goal. The user should experience the access to the product's function as aesthetically pleasing as possible. (94)

This view challenged existing writing and practice at the time, in which the understanding of affordances was limited "only to the perceptual-motor skills of the user and the characteristics of the environment, but … leave the intention and the feelings of the user outside the basic concept" (93). Overbeeke and Wensveen thus argued that interaction design should aim to be irresistible to users—"Interfaces should be surprising, seductive, smart, rewarding, tempting, even moody, and thereby exhilarating to use" (94).

Petersen, Hallnäs and Jacob (2008) also recognised the limitations of focusing on function and efficiency. They saw the aesthetics of interaction as being concerned with more than just appearance. Like Overbeeke et al. (2002), they too observed a shift in focus from concrete aspects such as function to less concrete ones such as emotion and aesthetics. They attributed this shift to the pervasiveness of interactive technology, which changed people's perspective of the computer as a tool for working to an ordinary object found in everyday life. This shift also made it necessary for computers (and other everyday technologies such as mobile phones) to cater to the average person; thus requiring those who work in HCI (as well as other digital media) to consider the emotional, experiential, and aesthetic qualities of interactions. Much of the research emerging as a result has focused on aesthetics. Petersen, Hallnäs and Jacob observed that the aesthetics is mainly perceived in two different ways within HCI, which they described as the "analytical HCI perspective" or "the interaction design perspective" (10:2).

The analytical HCI approach to aesthetics is concerned with experience. Here the view of aesthetics is influenced by art theory. Studies on this are primarily critical and empirical approaches to examining "aesthetic experience in behavioral science". The interaction design approach, on the other hand, is concerned with expression. This view takes into consideration how aesthetics influences the way in which interfaces and the other elements of interaction design are expressed. The expressiveness of things, or the inherent expressions of the designed object itself, is considered by Petersen, Hallnäs and Jacob to be aesthetic realism. Conversely, they viewed the expressiveness of the use of things, or the experience of the designed object, as aesthetic pragmatism. Aesthetics of interaction combines both these perspectives, with experience and expression seen as equally important:

> In all kinds of design, there is a double perspective of aesthetics: the expressiveness

> of the things, the systems we design, and the expressiveness of the use of these. We design things, but we also implicitly design acts of use. The expressiveness of use is of focal interest for the aesthetics of interaction. This means that we have to revisit the notions of form, expression, and experience and try to understand them from a somewhat different perspective. (10:2)

The dichotomy of expression and experience also appeared in Lenz, Diefenbach and Hassenzahl (2014). They reviewed 19 approaches to the aesthetics of interaction from the disciplines of HCI, interaction design, and industrial design, categorising the attributes each of these used to describe 'good' interaction. These 19 approaches fell under two main categories; two of the 19 approaches fell under both of these. One category "dealt primarily with detailed spatio-temporal attributes of interaction sequences (i.e., action-reaction) on a sensomotoric level"; these were primarily the characteristics of physical interaction (i.e. expression). The other dealt with "the experiential level, the feelings and meanings an interaction is enveloped in rather than the interaction itself", focusing on the perceptions and emotions of users generated during the interaction (i.e. experience) (634). Lenz, Diefenbach and Hassenzahl compared these two categories to two of the three levels of interaction identified by Hassenzahl: the do-level, the motor-level, and the be-level (Hassenzahl 2010, cited in Lenz, Diefenbach and Hassenzahl, 630).

The do-level (also called the 'What') refers to the user's goal-orientation. It "deals with the specific things individuals want to achieve, such as preparing a cup of coffee, and the necessary functionality needed from a product". The motor-level (also called the 'How') refers to the sensory- and motor-related aspects of the physical interaction, or "the concrete sequence of operations to be performed to achieve a do-goal". The be-level (also called the 'Why') refers to the experiences and meaning the user derives during or as a result of the interaction, including "psychological needs as well as emotions created and mediated through interaction". Lenz, Diefenbach and Hassenzahl viewed the expression perspective as similar to the motor-level and the experience perspective as similar to the be-level. (630)

In general, it seems that the notion of aesthetics in HCI and interaction design has been explored in some depth, although continued examination is needed for the concept of aesthetics of interaction to evolve further. It is worth mentioning too that the works reviewed here in this section parallel the findings in the earlier part of the literature review on aesthetics, in particular that experience is comprised of the sensory, emotional, and intellectual.

Interactivity

This section consists of three main parts. "Defining interactivity" explores the various definitions of interactivity in a variety of disciplines, including technology, human-computer interaction (HCI), instructional design, narratives, communication and media, art, and video games. It also includes a detailed examination of Sohn's (2011) view of interactivity. "Interactivity and communication" traces the history of human communication in relation to interactivity. "Interaction, interface and interactivity" provides an overview of the design disciplines that have emerged as a result of new 'interactive' technologies. "Interactivity and the search for the perfect simulation" discusses the role of interactivity in narratives, simulations, presence, immersion, and experience.

Defining interactivity

Research on interactivity has grown exponentially since the 1990s and can be found across a wide range of disciplines, from media to education (Koolstra and Bos 2009). Downes and McMillan (2000, 158) observed that the word 'interactivity' is used indiscriminately in both popular and scholarly literature and there are "few or no attempts to define it", while existing definitions are "often contradictory". They also acknowledged that it is difficult to narrow interactivity to a single definition (159). In his book *The Language of New Media*, Manovich (2001, 55) criticised the term 'interactive' as being "too broad to be truly useful", noting that he had avoided its use in his book for that reason. Addressing the tautological meaning of the word, he pointed out that since "modern HCI allows the user to control the computer in real-time by manipulating information displayed on the screen," it is "meaningless" to refer to computer-based media as interactive (55). The lack of a clear consensus regarding interpretations of interactivity suggests that it is appropriate and necessary to look at existing interpretations across a variety of disciplines.

General definitions of interactivity

General definitions of interactivity are fairly broad, and make references to both human-human and human-computer interaction. The Merriam-Webster online dictionary, for example, states that 'interactivity' is a noun derived from 'interactive', where 'interactive' is defined as "designed to respond to the actions, commands, etc., of a user" (suggestive of human-computer interaction) or "requiring people to talk with each other or do things together" (human-human interaction). Both the Merriam-Webster and Collins online dictionaries refer to the notion of a two-way dialogue in their definitions of 'interactive'. Merriam-Webster defines 'interactive' as "of, relating to, or being a two-way electronic communication system (as a telephone, cable television, or a computer) that involves a user's orders (as for information or merchandise) or responses (as to a poll)", while in Collins it is "allowing or relating to continuous two-way transfer of information between a user and the central point of a communication system, such as a computer or television". One can assume, then, that interactivity is present in any of the following scenarios:

» Where two or more people talk to each other or do things together;
» Where a machine responds to the actions, commands, etc., of a user as a result of its design; or
» Where there is a continuous two-way transfer of information between users via a communication system or machine.

The first scenario can also be described as direct, real-life human-human interaction. The second scenario is representative of a human-computer perspective and is generally focused on behavioural response. An example of this can be found in Betrancourt (2005), who studied the control and interactive behaviour dimensions of interactivity in relation to animation, where control determines the pace and direction, while interactive behaviour determines the content. The third scenario represents a communication and media perspective, in which human-human interaction is mediated. In this context, the interpretation of interactivity is akin to that of "personal communications (verbal and non-verbal) over different media (FtF or CMC) (Burgoon et al., 2002)" (Ge, Law and Huang 2012, 117).

Fornäs (1998, 31) offered three interpretations of interactivity that relate to the above: "Interactivity is a notoriously polysemic concept, that may either emphasize the social interaction between media users, the technical interaction between users and machines or the cultural interaction between users and texts." The second interpretation correlates with the human-computer interaction perspective, while the first and last interpretations relate to the communication and media perspective. All three interpretations relate to mediated interaction and exclude real-life human-human interaction.

Interactivity in technology and human-computer interaction

Where technology and human-computer interaction (HCI) are concerned, the general consensus seems to be that interactivity occurs during, or as a result of, a two-way dialogue between humans and computers. This notion of a two-way dialogue is supported by both industry and academia. Many researchers agreed that interactivity should involve some kind of two-way exchange or dialogue (Crawford 2002; Downes and MacMillan 2000, 167; Quiring

2009, 901). Industry associations seem to concur. Self-touted IT education website Techopedia.com, for example, defines interactivity as "the communication process that takes place between humans and computer software" (Interactivity 2018). The Interaction Design Association website also addresses the interactivity between humans and computers: "Interaction Designers strive to create meaningful relationships between people and the products and services that they use, from computers to mobile devices to appliances and beyond" (About & History 2018).

There are some who disagree with the notion of the two-way dialogue. Gee suggested that interactivity can occur in unidirectional contexts as well—he explained that it is possible to interact with a painting (Gee 2007, 93). Sohn (2011) proposed that interactivity should be considered as multidirectional (1323) and our understanding of it should be expanded to include "any interaction involving humans, whether direct or mediated" (1325). Ge, Law and Huang (2012, 117) argued that "interactivity is a dynamic process that allows exchanges not only between human and computer, but also among people through computer systems, involving control or ability to act". In other words, the notion of a two-way dialogue between humans and computers does not take into account situations where computers are merely tools that facilitate dialogue, rather than participants in the dialogue. These various perspectives seem to suggest that referring to interactivity as a two-way dialogue between humans and devices is limiting.

Interactivity in instructional design and e-learning

Like HCI, the field of instructional design also subscribes to the notion of the two-way dialogue between humans and computers. For instance, Gearhart stated that interactivity "refers to the interaction between the learner and the instructional source" (Gearhart 2012, 83). In her study of interactivity in online courses, she noted that interactivity in online courses largely dealt with print and digital media, and that such interactivity "is more predesigned and programmed, needing to prompt and engage learners" (Gearhart 2012, 83). As the use of technology becomes more prominent in instructional design, interpretations of interactivity often incorporate references to both learning and technology. One example is Smith and Olkun (2005, 94), who described interactivity as requiring "two necessary and sufficient components, a) active perception and b) working with a 'closed feedback loop' toward a goal that can be verified with your senses".

Interactivity in narratives

From a narrative perspective, interactivity "can be interpreted figuratively as well as literally" (Ryan 2001, 16). Ryan distinguished between these two interpretations in her book, *Narrative as Virtual Reality*. In the literal interpretation, interactivity refers to "the textual mechanisms that enable the reader to affect the 'text' of the text as a visible display of signs, and to control the dynamics of its unfolding" (17). This perspective parallels Betrancourt's behavioural approach to interactivity[28] and is more closely aligned with the human-computer definition of interactivity. The figurative interpretation, on the other hand, relates more to the communication and media perspective but in a different way. It is less focused on the interaction between the reader and the author, and more focused on the interaction between the reader and the text. In this context, interactivity "describes the collaboration between the reader and the text in the production of meaning"; in other words, interactivity occurs when our mental processes construct meaning and imagery from the written text, and is therefore inherent in reading (Ryan 2001, 17).

Ryan's examination of the characteristics of interactivity is worth mentioning here, particularly weak versus strong interactivity. In its weak form, she wrote, interactivity "is a choice between predefined alternatives"; in its strong form the reader "performs a role through verbal or physical actions, thus actually participating in the physical production of the text" (Ryan 2001, 17). Ryan's strong form of interactivity resembles the interactive behavioural dimension of interactivity discussed by Betrancourt (see page 94), but the weak form does not completely overlap with Betrancourt's control dimension.

Interactivity in communication and media

In communication and media, interactivity sometimes seen is as a dimension of telepresence, where telepresence is "*defined as the experience of presence in an environment by means of a communication medium*" (Steuer 1992, 76, emphasis in the original). Steuer (1992, 80) considered interactivity to be one of two major dimensions that determine telepresence, the other being vividness[29]. In the context of his paper, Steuer defined interactivity as "the degree to which users of a medium can influence the form or content of the mediated environment". Steuer (1992) emphasised

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[28] See page 63.

[29] See page 104 for more on telepresence and presence.

that vividness and interactivity "refer only to the representational powers of the technology, rather than to the individual" (80), later clarifying that the definition of interactivity he used is not about "*engagement* or *involvement*" (84, emphasis in the original). In other words, vividness and interactivity are qualities of the technology, rather than qualities of the *interaction* between the individual and the technology. Steuer also identified others who have made references to interactivity or to its ability to control or modify the environment: Sheridan listed "control of sensors relative to environment" and "the ability to modify the physical environment" as two of five variables that affected telepresence; Zeltzer listed "autonomy (human control)" and "interaction (real-time control)" as two variables that could be used to describe graphic simulation systems; Michael Naimark, like Steuer, identified two dimensions influencing telepresence, but used the term 'realness' instead of 'vividness'; and Laurel and Rheingold "make similar distinctions". (Steuer 1992, 80)

Steuer's interpretation of interactivity—as a means of describing the extent to which a user can control the content in a technology or medium—makes it relatively easy to distinguish between older forms of media (e.g. television, radio, and newspapers) and newer forms of media (e.g. computers). The evolution of technology and interactivity, however, has made it increasingly difficult to make distinctions between present-day media, particularly on the basis of their supposed interactivity (Fornäs 1998, 31). The difficulty, Fornäs argued, is that all media are interactive:

> Every medium is to some extent technically and culturally 'interactive', by inviting its users to an activity that includes an interaction both between the medium (both the machine hardware and the textual software) and its users and between those different individuals who are connected by the mediation in question. That interactivity consists of a series of choices—of commodities, channels, programmes, genres, texts, times, places and reception modes. It implies a co-production—of knowledge, meaning, experience, identity and even new cultural expressions in those words, gestures or songs that might spring from this media use. It also includes the shaping of specific intersubjective social relations—of interpretive communities and other interactions between different media users. (31)

Thus, Fornäs (1998) proposed that interactivity be seen as something that occurs when an individual uses media, rather than a characteristic of media: "Interactivity resides more in the relation between media and their users than in the media themselves." (31) He argued that if the presence of interactivity during media use is dependent on *how* an individual uses the medium, and not on the medium itself, then all media can be used interactively, regardless of whether they possess supposed interactive features:

> A book may be just read from beginning to end, or it may be worked through and filled with notes in the margins and across the printed text. A karaoke video may either be 'passively' consumed by a watching and listening audience or 'actively' used by a singer. Different technologies only have varying potentials for interactive use, just as different individuals are variously prone to be interactive in their use of media texts, or as different contexts are more or less inviting to such interactive practices. (32)

In other words, interactivity is what occurs when an individual uses a medium, and is not simply a characteristic of a medium. Thus, interactivity is not regarded a new phenomenon that is unique to digital media, but one that is present across all media (Fornäs 1998, 31).

Media theorist Lev Manovich (2001) focused on the characteristics of the interactivity itself after having observed, "it is much more difficult to deal theoretically with users' experiences" of interactive media (i.e. human-human communication via a media device) (56). His book, *The Language of New Media*, distinguished between open and closed interactivity. In open interactivity, "both the elements and the structure of the whole object are either modified or generated on the fly in response to the user's interaction with a program" (40). With closed interactivity, which Manovich also referred to as "branching (or menu) interactivity", the interactive elements are already generated and the user simply determines the order in which they are accessed (40). To an extent, Manovich's open and closed interactivity is similar to the concepts of strong and weak interactivity as proposed by Ryan (2001)[30].

Lushetich (2007) observed that Manovich's ideas also appear similar to those of cognitive scientist Donald Norman, who wrote about shallow and narrow structures—in which the number of choices is limited and each choice produces a simple response—and deep and wide structures—where each choice can generate one of many possible responses. However, Lushetich also clarified that closed structures may not necessarily be shallow and narrow, citing chess as an example of a closed structure that is also deep and wide, "whereby every move has a number of possible counter-moves, each of which opens up a number of possible options in turn". (2007, 11-12)

Interactivity in art

Views on interactivity in art differ quite dramatically from those in human-computer interaction (HCI) and instructional design. Firstly, while interactivity is seen as something that

[30] See page 65.

can be added to experiences in HCI and instructional design, in art interactivity is viewed as being inherent in all experiences[31]. Manovich (2001), for example, commented that all art is interactive because the inherent ambiguity of art requires the viewer (or user) to interact with it in order to derive meaning from it:

> All classical, and even more so modern, art is 'interactive' in a number of ways. Ellipses in literary narration, missing details of objects in visual art, and other representational 'shortcuts' require the user to fill in missing information. Theater and painting also rely on techniques of staging and composition to orchestrate the viewer's attention over time, requiring her to focus on different parts of the display. With sculpture and architecture, the viewer has to move her whole body to experience the spatial structure. (56)

Lopes (2001) suggested that the use or presence of digital technology is irrelevant to the interactivity of an artwork, stating:

> That we interact with computers in the making and appreciation of art is hardly remarkable once we realize that making and appreciating art are always interactive activities. If attributions of interactivity are questionable, it is not because computer-based art is not interactive, but because just about any process for making or experiencing art is interactive. (67)

Likewise, James Paul Gee (2007) proposed that interactivity is present in the act of viewing a painting. In his explanation of spaces, Gee wrote that adding content to a space helps to define it. Once a space has content, we can view it "in terms of *content*" or "in terms of how people *interact* with that content or with each other over that content" (93, emphasis in the original). Using a painting of a haystack by Monet as an example[32], Gee declared:

> The same distinction can be made for a painting. We can view a painting as content, that is, as a work of art designed in a certain way. Notice that content always brings up the issue of design, since someone has to design the content. Or we can view the painting in terms of how people react to, use, or interact with the painting and with each other over the painting. To say of a Monet painting that "It is made up of a myriad of pastel dabs" or "It depicts a hayfield in the early morning light" is to comment on its content (and the design of that content). To say that the painting "Makes people feel they are present in the field" or that "Most people appreciate the painting best when they stand at a fair distance from it" or that "People strongly disagree in terms of how realistic they think the painting is" is to comment on how people interact with the painting or with each other over the painting. (93)

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[31] This is based on Stecker and Gracyk's proposition that all experiences are aesthetic experiences, hence the view here is that interactivity is inherent in all experiences. This view is also similar to that of Fornäs (1998).

[32] Monet did several paintings of haystacks, an example of which can be found at: http://www.metmuseum.org/toah/works-of-art/29.100.109. However, this may not be the actual painting Gee had in mind.

Gee's commentary on how we interact with paintings relates to the concept of aesthetic distance. Kwastek (2013, 43) noted that previously held views regarded "aesthetic distance as a necessary condition of aesthetic experience". Accordingly, the concept of aesthetic distance requires that the interactivity present in real-life experiences be seen as being discrete from the interactivity present in aesthetic experiences. This is now being challenged by interactive art, particularly when it involves the use of technology. As technology has evolved, the distance between the viewer and the viewed has decreased over time. One could even say that the distance is at zero, or even 'in the negative'—with virtual reality technology, for example, we are not simply closer to what we are viewing, we viewing it from the inside. Aesthetic distance is viable concept in aesthetic experiences that happen in the real world, but it is less so in experiences that happen in virtual worlds—with virtual experiences, the concept of immersion is more appropriate[33].

Secondly, unlike in HCI and instructional design, interactivity is not seen as a measure of the quality of an experience in the discipline of art. HCI and instructional design generally assume higher levels of interactivity result in better quality experiences[34] (Cyr, Head, and Ivanov 2009; McGuigan and Normand 2011; Teo, Oh, Liu, and Wei 2003). However, in art the quality of an experience is determined not by the *level* of interactivity, but rather, how *suitable* the combination of interactivity is to eliciting the intended experience. Kwastek (2013) discussed this in the context of interactive art—she emphasised that interactivity should not be viewed as "an ideal way to configure aesthetic experience" (xix), since this can result in a tendency to "create ranking scales" of interactivity, in which face-to-face communication is viewed as "the ideal form of interaction"[35], ultimately leading to the idea that the level of interactivity directly influences quality. Kwastek suggested that such a view is problematic, because the aesthetics of interactive art cannot be determined by simply ranking the level of interactivity; doing so fails to take into account the artists' intention to compare and contrast mediated and face-to-face interaction. (120-121)

Thirdly, interactivity in art is subjective, in that it is determined by an individual's perspective of an experience, rather than an objective description of a medium. The latter approach generally leads to interactivity being seen as something that is—and should be—measured,

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[33] See page 104.

[34] There are exceptions to the rule. See Burgoon et al. (2002).

[35] See also Burgoon et al. (2002).

while the former, as Kwastek (2013, xvii) described it, puts "the artistic work and the recipient's experience of the latter at center stage". Kwastek showed the importance of personal aesthetic experience in relation to interactivity and examined this alongside the aesthetic notion of subjectivity, thus providing "a dual basis for an understanding of interactivity that can be applied to all the relevant artistic disciplines, including visual art, sound art, Internet art, and performance art" (ix).

There are those who take the opposing view, rejecting the idea that interactivity is subjective and determined by individual experience. They view interactivity as having characteristics that can be objectively assessed. Lopes (2001), for example, focused on the inherent structure of the artwork rather than the users' experience of the artwork's structure:

> It should be kept in mind that what is in question here is not the structure of a work as its user experiences it, for that is "interactive" in some broad sense for all works of art, but the structure of the work itself. Only the structure of strongly interactive artworks is partly determined by what the interactor does in accessing the work. By contrast, the structure of merely weakly interactive works is independent of how that structure is accessed. (68)

Penny, on the other hand, differentiated between instrumental interactivity and enactive interactivity[36] (Joseph, Hugain-Lacire and Ziegler 2013). Instrumental interactivity refers to "modalities which are deployed as a mechanism for exploring 'content'," where the "mechanisms used for exploring 'content'" are akin to the features of the work. Enactive interactivity refers to "modalities which themselves contribute to the accumulated meaning or experience of the work" and takes into account the aspects of the work that allow users to experience and derive meaning from it as a whole. These include the context of the work (e.g. social context, cultural influence, artist's intention, etc.), the user's ability to interpret those features, and the semiotic qualities of the work. (Joseph, Hugain-Lacire and Ziegler 2013)

[36] Discussing Penny's instrumental and enactive interactivity in conjunction with Manovich's open and closed interactivity can provide a clearer explanation of both theories. Modalities of instrumental interactivity and enactive interactivity change in relation to whether interactivity is open or closed. However, the changes occur in different ways. In closed interactivity, visuals that are used *for exploring content* (e.g. buttons)—modalities of instrumental interactivity—are more likely to be static, maintaining a fixed appearance and position (i.e. the image of the 'home' button looks the same and is always in the same place on a website, even across different webpages). In open interactivity, visuals that are used *as content* to convey meaning (e.g. animations)—modalities of enactive interactivity—are more likely to be dynamic, where appearance and position changes constantly (i.e. the image of a non-player character (NPC) is constantly changing in open world video games such as *Grand Theft Auto V*).

Interactivity in video games

Theories of interactivity applied to video games have been taken from interactive art. This is partly because the delineation between interactive art and video games is not clear-cut, and there has been plenty of debate in relation to this, particularly in mainstream media (Ebert 2010; Jones 2012; Smuts 2005; Stuart 2012). Tavinor (2009) applied Lopes' theory of weak interactivity and strong interactivity to video games, stating that "videogames do count as strongly interactive in Lopes' sense". He used *Grand Theft Auto IV* to support his claim, explaining that since "players shape what actually occurs in the game", the video game is more like "a script that is interpreted" than "a template from which the appreciated work is shown". Tavinor also acknowledged technology is necessary in order for interactivity to exist in video games. Yet, as we saw in the previous section, interactivity in art can occur with, and without, the use of technology.

A number of digital game theorists also discussed interactivity together with aesthetics. Dickey (2012) provided an overview of some key scholars' work: Mortensen saw the game interface as being the "main element in game aesthetics", and proposed that interface, narrative and visual design collectively support player-game interactivity; Crawford had the view that "interactivity is the essence of a digital game" and prioritised player-game interactivity over game content, because the former promotes "more organic interaction"; and Myers maintained that both game content and player-game interactivity affect the aesthetics of a game. (Dickey 2012, 103)

Researchers also looked at the relationship between social interaction and interactivity in digital gaming. Vorderer, Hartmann and Klimmt (2003) looked at the role of competition in playing video games, while Jansz and Martens (2005) examined the social context of playing video games at a LAN event, where players play both face-to-face and online at a common location.

Interaction versus interactivity

A discussion about interactivity would be remiss without a discussion about interaction. Sohn (2011, 1325) described interaction as "a multi-layered process" that requires perception (i.e. the two interacting people would perceive each other), and proposed that the term 'interaction' only be used to refer to human-human interaction. He differentiated this from computer-computer interaction, which is simply "a process of electric signal exchange at a single level" (1325). He saw all human-human interaction (both direct and mediated) as occurring in three dimensions—sensory, semantic, and behavioural—and thought interactivity might occur simultaneously in all three dimensions (1325-1326). An in-depth review of Sohn's views on interactivity can be found in the next section (see "Sohn's views on interactivity").

Others have also distinguished between interaction and interactivity, but in different ways. Neuberger regarded interaction as "a process that actually happens" and interactivity as "only a potential process" (Kwastek 2013, 6). The document "Deliverable 1.3: Description Models for Unstable Media Art" observed that on the one hand, there are those who view the notion of interactivity as being related to the level of control a user has when using an interface, while on the other, interaction is assumed to be a "mutually reciprocal communication process" between two or more users, or between users and machines (Deliverable 1.3 2003, 17). In its examination of the terminology relating to interactivity and user interaction, it proffered Wagner's definition of an interaction, which stated that an interaction consists of two reciprocal events requiring at least two objects and two actions, and where the objects and events mutually influence each other[37]. The document went on to explain that while interaction is concerned with human behaviour, interactivity is viewed as a characteristic of technology. (17)

Sohn's views on interactivity

A close reading of Sohn (2011) is included here since it has had a significant influence on this thesis. The most important and relevant aspects of this paper are discussed in detail here. Sohn acknowledged that existing definitions of interactivity were problematic, and noted that other scholars shared similar concerns—namely that interactivity "needs to be expanded beyond specific media or contexts (e.g. the internet) to reflect a more general communication experience" (Sohn 2011, 1321). To accomplish this, Sohn proposed starting from a "common experiential domain—*what constitutes a person's perceptual experience of interaction, namely perceived interactivity*—rather than focusing on fast-changing technologies" (1321, emphasis in the original). The three dimensions of interactivity he proposed—sensory, semantic, and behavioural—were developed in response to three common assumptions about interactivity.

The first assumption is "interactivity is a medium characteristic". Sohn noted that interactivity is treated by many scholars "as a technological characteristic" which is specific to certain media (usually the computer or the Internet) and, as such, is used to refer the media's capability.

[37] This is taken from the original article by Wagner (1994, 8). It is worth noting that the other quote in this document on interactivity was not included as it was found to have been wrongly attributed to Wagner (1994).

This is a mechanical approach to interactivity, and is limited in two ways. First, it considers potential interactivity (how the features of a website is intended to work, for example) but not actual interactivity (the user's experience of the interactivity, which varies from individual to individual). Second, defining interactivity using "the existing features or functions of a particular medium… may not be useful for other media with different characteristics". This would also make it difficult to compare different media with each other, and to compare different old and new versions of the same medium (if the new versions have additional features or functions). Constantly adding to the list of dimensions of interactivity would also "obscure rather than clarify the meaning of interactivity". (1321)

The second assumption, "interactivity is in the eyes of the beholder", relates to the view that interactivity is "a user's *perceptual experience* rather than a technological attribute" (1322, emphasis in the original). This perceptual experience refers to "a person's psychological state during the interaction with a medium" and "is influenced not only by the medium's attributes, but also by some dispositional or situational characteristics". The dimensions of interactivity commonly used in this context include control, directionality, and synchronicity (as perceived by the user). However, these are derived from the functions associated with the Internet and are generally used to determine the presence of particular features or functions, rather than overall usability, and do not really address "what the nature and structure of the perceptual experience is". (1322)

"Interactivity is a process" is the third assumption. Sohn first cited Rafaeli, saying that interactivity is the result of a "reciprocal interaction" rather than "a sequence of fragmented action/reaction"[38] (1322-1323). Thus, the mere presence of the aforementioned two-way dialogue is not indicative of interactivity; for interactivity to be present, there had to be a "cumulative exchange of semantic information with mutual interest and involvement". Sohn noted, however, that although this definition is ideal for "computer-mediated communication", it is not suitable for mass media. It also limits "the scope of interactivity only to a one-to-one interaction form" that is sequential in nature, while failing to address situations where the dialogue is between three or more parties "in an indirect, multi-directional way". Sohn questioned if interactivity is present in situations such as where participants "may still feel

[38] A similar distinction was made earlier between aesthetic experiences—which I referred to as "a series of synchronised and connected events"—and stand-alone events, which are unsynchronised and disconnected. I would venture to suggest that which occurs in aesthetic experiences be called interactivity, while that which occurs in isolated events is called interaction.

that they are involved with an active social interaction, which enhances their perception of interactivity". He also cited Rafaeli and Ariel, who suggested that interactivity "may still exist when a response occurs at delayed time or physically removed location". (1323)

Sohn concluded that these three assumptions "represent the essential elements that constitute (mediated) interaction—*medium*, *user*, and *process*" and that all of these are necessary for "meaningful interaction" to occur (1323-1324). At the same time, he also observed that in an attempt to eliminate some of the confusion surrounding the concept of interactivity, scholars have suggested that human-computer interactivity and human-human interactivity are different and should not be treated the same way. Since human involvement is a common factor between the two, Sohn questioned whether "the nature of human-machine (or medium) interaction is truly distinctive from that of human-human interaction". He pointed to research that showed people sometimes behave as though computers have human qualities, which suggested that the differences between the experience of human-computer and human-human interactivity "may not be so distinguishable in people's mind". In other words, what actually happens is less important than people's perceptions of what is happening. Thus, Sohn proposed that we consider interactivity in the context of "perceptual experience" in order to develop a concept of interactivity that has "a clearer, more intuitively understandable boundary and inner structure" and "is applicable to a wide variety of interaction situations". (1324)

Combining the notion of interaction and perception, Sohn described the processes that occur during a perceptual experience: first, sensory perception occurs (in this context, perception occurs during interactions that involve people), during which "information acquired from the environment via the sense organs is transformed into experiences of objects, events, sounds, tastes, etc." (Roth and Bruce 1986, quoted in Sohn 2011, 1325); second, information gathered as a result of this sensory perception is then interpreted by the person perceiving the experience; lastly, a behavioural response is generated as a result of the interpretation. (1325-1326)

In his discussion of the sensory dimension, Sohn cited some evidence of links between sensory experience and perceived interactivity (Morrison 1998; Downes and MacMillan 2000; Johnson et al. 2006, all cited in Sohn 2011, 1326). The evidence cited in relation to the sensory dimension was primarily related to the visual sensory mode. Animated visuals, for instance, were perceived to be more interactive, as were visuals that were perceived as being more vivid[39].

[39] See also Steuer on vividness and interactivity, on page 65.

Unable to determine "what kinds of sensory information help elevate perceived interactivity and to what extent", Sohn concluded that further empirical research was required (1326-1327).

When discussing the semantic dimension, Sohn mainly focused on how we derive meaning from our interactions with media or other people. A medium might be perceived as interactive, for example, if it offers "vivid sensory information" (as mentioned above) along with "personally relevant messages (e.g. 'Welcome back, Jane!')" (1327). In the semantic dimension of interactivity, meaning is "conveyed not only by texts, but also by non-verbal elements like symbols or icons" (1328). However, perceived interactivity is not only affected by meaning; meaning must also be accompanied by relevance (Rafaeli 1988, cited in Sohn 2011, 1327) and "reciprocally sustained involvement" (Goffman 1957, quoted in Sohn 2011, 1327).

Behavioural engagement, Sohn noted, has a significant influence on perceived interactivity (1328). With the behavioural dimension, Sohn explained that it "focuses on the extent to which users perceive they can behaviorally [sic] engage in an interaction situation" (1329, emphasis in the original). He also pointed out that some scholars have linked behavioural engagement to the amount of control the user has during the interaction, but expressed his disagreement, stating, "control is an outcome of reciprocal interaction, not its intrinsic aspect—the more reciprocal an interaction becomes, the greater control an actor has over the interaction process, not vice versa". He also clarified that the behavioural dimension is not the same as affordance, but rather a subset of it; affordance refers to all the possible actions the user perceives as being available, while the behavioural dimension is focused only on those related to behavioural engagement. (1329)

Interactivity and communication

> All human technologies … are embodiments of human ideas.
> —Paul Levinson (Levinson 2001, 116)

We live in what some have called an "information age" (Castells 2011; Rockenbach and Fabian 2008). Others have declared an "information revolution" has occurred (Levinson 2001). These terms make it seem as though information has only just become important, when it has always been central to everything we do. As Levinson (2001, xi) pointed out,

> All life, indeed, operates on information. What characterizes human life is that we presumably are aware of information and its various modes of conveyance—yet so ubiquitous is this information, like the very air around us, that we often take no notice of its most profound consequences, the ones that arise when the currents of conveyance change.

We *acquire* information any time we interact with an external object, person or place, but the *exchange* of information only occurs when we interact with other people (or, one might argue, with animals as well). On a personal level, a list of the different types of information we use might include:

» information about ourselves (e.g. personal data, emotions)
» information about others (e.g. gossip)
» information about what we know (e.g. our own internal knowledge)
» information about what others know (e.g. external knowledge to be acquired)
» information about the world (e.g. facts).

The exchange of information between people is generally referred to as *communication*. Communication involves one person giving information to and receiving information from another person. The online Merriam-Webster dictionary defines communication as "the act or process of using words, sounds, signs, or behaviors [sic] to express or exchange information or to express your ideas, thoughts, feelings, etc., to someone else". We might say, then, that *expression* is how we share information about ourselves (i.e. our thoughts and feelings), *exploration* is the search for information in order to increase our knowledge (i.e. our personal store of information), and *perception* is how we understand and interpret the information we receive. Communication typically requires both expression and perception, and sometimes involves exploration. Prior to the invention of the printing press and digital technology, this was mainly done face-to-face. Technology, beginning with paper and eventually computers, allowed the exchange of information between people to be mediated.

The significant role of technology in the evolution of communication tends to paint the history of communication as a technological one, but it is arguably better described as "a phenomenon driven by fundamental human communication needs—our needs for information, entertainment, self-expression, and relationship building" (Sohn 2011, 1321). This section takes this one step further, by proposing that the pursuit of interactivity in technology and media is not only driven by the human need to communicate, but also a desire to overcome the limitations of real-life and real-time communication. To that end, the impact of technology on human communication will be examined using an interactivity lens, with a focus on the interactivity with between people and information, as well as the interactivity between people that occurs during the exchange of information.

The historical details of the communication technologies described in this section are drawn primarily from the works by Derek Cheung and Eric Brach, Paul Levinson and John Naughton. In *Conquering the Electron: the Geniuses, Visionaries, Egomaniacs, and Scoundrels who built our Electronic Age*, Derek Cheung and Eric Brach (2011) traced the history of each of the inventions that made today's electronic age possible. Paul Levinson (2001) explored the history of information technology in his book, *The Soft Edge: A Natural History and Future of the Information Revolution*, while John Naughton (2012) looked at the history of the Internet in his book, *From Gutenberg to Zuckerberg: What You Really Need to Know About the Internet.* (These works provide a comprehensive and fascinating overview of the history of communication and technology, and are recommended for those who wish to delve into further detail.)

Speaking

In the absence of print or digital media, most communication in ancient Greece occurred directly, face-to-face, in the real world, in real-time (Thomas 1992). Even though the written word was in use at the time, speaking (or oration) was preferred and even considered superior. Oration was the best method of mass communication available at the time[40], and ancient Greek philosophers were particularly gifted at this[41]. However, the major problem with oration was that there was no way of recording, copying, or distributing what was said. Orators had to be able to "deliver long speeches from memory with unfailing accuracy" and this made it necessary for them to master "the classical art of memory" (Yates 2014, 18). This art of memory required significant training to hone "faculties of intense visual memorization", in which "the art and architecture of the ancient world" were used as storage containers for information (Yates 2014, 20). A description of the process follows, as described by Cicero (quoted in Yates 2014, 37-38):

> Places are chosen, and marked with the utmost possible variety, as a spacious house divided into a number of rooms. Everything of note therein is diligently imprinted on the mind, in order that thought may be able to run through all the parts without let or hindrance. The first task is to secure that there shall be no difficulty in running through these, for that memory must be most firmly fixed which helps another memory. Then what has been written down, or thought of, is noted by a sign to remind of it. This sign may be drawn from a whole 'thing', as navigation or warfare, or from some 'word'; for what is slipping from memory is recovered by the admonition of a single world. However, let us suppose that the sign is drawn from navigation, as, for instance, an anchor; or from warfare, as, for example, a weapon. These signs are then arranged as follows. The first notions is placed, as it were, in the forecourt; the second, let us say in the atrium; the remainder are placed in order all round the impluvium, and committed not only to bedrooms and parlours, but even to statues and the like. This done, when it is required to revive the memory, one begins from the first place to run through all, demanding what has been entrusted to them, of which one will be reminded by the image.

For the speaker, this act of generating detailed visual renderings of people, objects, and architecture in the mind was a great feat of imagination, and interactivity was necessary for this to occur. However, this interactivity did not require the use of any media. Instead, it took place within a virtual space, between the speaker and other entities (e.g. objects, people, and

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40 Speaking was also possibly the only method of mass communication available, given that the written communication was not widely distributed or used (see Thomas 1992).

41 This was likely because "A civilized man in Greece (and indeed Rome) had to be able, above all, to speak well in public." (Thomas 1992, 3)

places, as well as information). This virtual space existed within the mind. In this context, there was interactivity between the speaker and the information stored in their memory, and also between the speaker and the audience. Since there was no way for information to travel directly from the speaker's mind into the minds of the audiences, the speaker had to interact with the information in his or her mind and translate this into words so they could communicate this to their audience when they interacted with them.

Oration had its advantages. It allowed speakers to simultaneously and instantaneously communicate with many people, although their audience numbers pale in comparison to those of popular YouTube celebrities today. However, unlike YouTube, oration required the speaker to communicate face-to-face with the audience in real life and real-time, and vice versa, since "any member of the audience was eligible to speak"[42] (Brockreide 1966, 37). This resulted in a rich experience for the audience. On the other hand, because oration had to happen in real-time[43] and in real life, there was only one way to access the information provided by the speaker—to be physically present at the event. This meant two things: firstly, the speaker was limited to reaching only those who could be physically present at his speaking events; and secondly, there was no way of someone acquiring the information given by the speaker unless he or she attended the speaking event in person. Because of this, the interactivity in oration was limited, since it is difficult to interact with more than one thing (or person) at a time.

Writing

The invention of writing addressed some of the problems with oration. First of all, it revolutionised the spread of information—the author of the information no longer had to be physically present to disseminate the information and the recipient of the information did not have to be physically present to receive it. As a result, the interaction between the author and the reader was no longer direct, but mediated. Second, writing also enabled authors to physically interact with information, instead of virtually in their mind. Finally, writing also allowed information to be replicated and distributed. Over time, this effectively meant that

[42] Such oration appeared to be, above all, a discourse between equals: "Public address then occurred predominantly among men who were approximately equal in social class, in political and legal opportunities, and in education. The major public address occasions, deliberative and forensic, were restricted to citizens. In politics, the audience consisted of Athenian citizens, and any member of the audience was eligible to speak." (Brockreide 1966, 37)

[43] Real-time communication is also called 'synchronous', and communication that does not occur in real-time is referred to 'asynchronous'.

information could reach a much wider audience, albeit over a longer period. The choice therefore became split between reaching a large audience immediately and synchronously via oration, or a large audience gradually and asynchronously via written text.

While the potential reach for oration was limited by the logistics involved in addressing a live audience (i.e. the size of the venue, the acoustics of the venue, the need for physical attendance, etc.), with written text the potential reach was limited by the high cost and low speed of producing copies of the information. At that time, books were copied by hand. This made the production (and reproduction) of books slow and laborious, as well as phenomenally expensive. As Naughton described it, books were, more or less, "the exclusive preserve of the rich and powerful—aristocrats, monasteries and medieval universities in the main" (Naughton 2012, 16-17). They were also prone to errors, "an inescapable by-product of manual copying" (Naughton 2012, 19).

The written format also meant that the direct communication between speaker and audience was lost, and the communication itself was no longer synchronous. This was the main reason Socrates was critical of writing. Socrates believed that the loss of direct communication between speaker and audience restricted dialogue "because it can give but one unvarying answer to questions posed to it—namely, the words already written" (Levinson 2001, 18). Another significant objection Socrates had was that "reliance on written communication atrophies memory" (Levinson 2001, 17-18). Although this may be valid to some extent, writing did allow greater cognitive effort to be spent on critical thinking by removing the burden of having to interact with information virtually in the mind. This benefit was highlighted with the invention of the printing press.

Printing

The most significant impact of the invention of the printing press by Gutenberg in the mid-1400s (Naughton 2012, 12-14) was that it allowed texts to be reproduced in physical form more quickly, more cheaply, and more accurately than with scribes. The printing press' ability to generate reproductions in large quantities meant that information could now be made widely available to the masses, rather than be concentrated in the hands of a select few (Levinson 2001, 20). Although it was still unable to restore the real-life or real-time communication that once existed between speaker and audience[44], printing was able to reinstate the reciprocity lost in the transition from speech to writing to some extent, by enabling the mass distribution of many different texts. As Levinson (2001, 30) pointed out, "The responsiveness and fluidity of local speech was simulated, to a degree, in the options for knowledge provided by the rapidly globalizing press." This partly allayed Socrates' concern "about the written word giving but one unvarying answer", since "great multiples of copies of many unvarying answers" were now available to the masses (Levinson 2001, 30).

This potential for mass distribution, combined with the newfound accuracy, consistency and permanence of printed text, made the "cumulative development" of knowledge possible and gave rise to what was perhaps the most significant outcome resulting from the invention of the printing press: the development of modern science (Naughton 2012, 19)[45]. The mass distribution of books and other printed material also made it necessary for people to acquire special skills to access the information contained within them (23). This resulted in "the emergence of two individuals hitherto almost unknown—the writer and the reader" (21). It also allowed the exchange of ideas to occur without any real-life social interaction: "Orality became muted, and the reader and his response became separated from a social context." (Postman 1996 quoted in Naughton 2012, 23) This shifted the function of communication from being about an interaction between two people, to an interaction between a person and information—and consequently led to changes in the kind of interactivity that occurred.

The changes in interactivity were also partly brought about by the lower costs of print production afforded by the printing press. However, these lower costs only applied to black-and-white printed text. As a result, people tended to interact with information in the form of text rather than visuals[46]. The dominance of text over visuals continued even after early forms of colour printing were developed because the profit margins of publishers tended to be prioritised over the quality of the reader's experience. Furthermore, most readers were unwilling (or unable) to pay extra for more images and better-looking books, although this gradually changed as printing technologies improved and prices continued to fall. The falling price of colour printing eventually became irrelevant once computers became widespread. Now,

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[44] This is probably why the arrival of the printing press did not render plays and speeches obsolete, even though their context of use and purpose were subject to change.

[45] Levinson (2001) had a similar opinion.

[46] Images were rarely used because this was prior to the invention of commercial black-and-white photography, so all images had to be illustrated and this was a slow and expensive process.

with smartphones and other mobile devices, it is cheaper and quicker to distribute full colour text and images via the Internet than in printed form.

The emphasis on text over visuals affected the interactivity between the writer and reader, the writer and the information, as well as the reader and the information. Readers of fiction, for instance, had to use their imagination to generate visuals from the words they read; this required them to interact with the text not just cognitively—to try and make sense of the words—but also imaginatively—in order to generate mental images to accompany the words. Writers of fiction had the opposite problem—they had to figure out how to translate the rich imagery of the storyworlds[47] that existed in their imagination into words that would adequately allow their readers to recreate those worlds themselves using their imagination. The interactivity between the writer and reader had to be filtered through not just language, but also the printed medium.

Photography

This changed after commercial black-and-white photography was invented in the 1800s (Newhall 2015), almost four centuries after the printing press[48]. With photography, it was now possible to communicate without the use of verbal or written language, albeit still through a printed medium. Photography changed how people interacted with information—both as creators and audiences. Prior to this, an artist (or illustrator) was required to render the image over a several sessions, making the accuracy of the resulting image subject to the artist's memory and skill. Since photography allowed images to be captured in real-time, permanent visual records—that were accurate and true-to-life—could be made of events as they happened, and of people at a specific point in time. Used with the printing press, photographic imagery could be disseminated to a mass audience through newspapers, posters and magazines. The ascendance of visual information had begun.

Then came colour. This was an obvious progression, since photography is intended to document real life, and real life is in full colour, not black-and-white. Colour also increased the attractiveness of visual information. Unlike text, which required the reader to read and

[47] Herman (2002, 14) defined storyworlds as "mental models of who did what to and with whom, when, where, why, and in what fashion to which recipients relocate—or make a deictic shift—as they work to comprehend a narrative".

[48] Note that successful attempts at capturing photographic images did occur prior to the invention of commercial photography.

the form the images in his or her mind, colour photos appealed to the viewer's emotions immediately. The addition of colour to photographs lent them a realism that previously existed only in real life, bringing communication yet another step closer to replicating reality. The desire for colour was such that prior to the invention of commercial colour photography, black-and-white photographs were hand-painted to add colour. This technique gradually fell out of favour after the Lumière brothers discovered how to take and develop colour photographs using the Autochrome process in 1907, and Kodachrome colour film was invented by Leopold Godowsky, Jr. and Leopold Mannes in 1935 (Rosenblum 2015).

The telegraph, telephone, phonograph, and radio

With printed forms of communication dominating the scene, communication remained a primarily visual affair until the telephone was invented in the 1870s. Although technically the transmission of sound was technically first made possible by the telegraph (which was patented in 1837), for the average person it remained a visual form of communication and an asynchronous one, since telegraph operators were required to create and listen to the audio transmissions (which were in Morse code), and then translate them from and into written text for telegraph customers. Only with the mass adoption of the telephone was it finally possible for people to interact with each other using sound rather than visuals, as well as synchronously over long distances. (Cheung and Brach 2011)

Our continuing attachment to the telephone suggests that the power of visuals in human communication is not absolute, even though in general we are quite convinced of it. There are several timeless reasons that explain why communicating via telephone is so appealing:

> The analog telephone quickly grew to be far dearer to the public's heart than the digital telegraph, mainly because it was both so personal and so easy to use. Telephones offered to every man, woman, and child the closeness of natural speech … once connected, both parties could converse at the same time, just as if they were face to face having an intimate chat. (Cheung and Brach 2011, 68)

Additionally, the arrival of the telephone tackled the key problems that printing had not been able to address—it made real-life and real-time verbal communication possible, without the need for both parties to be at the same physical location. Communication was possible even for those separated by vast distances. Moreover, it was also relatively cheap (once its use became widespread). Of course, the telephone also had its faults, particularly in the early days of its adoption. It suffered from poor sound quality and lacked the permanence of printed text (that is, until Edison invented the phonograph in 1878). (Cheung and Brach 2011, 68)

The next big change in sound-based communication was the radio. Radio technology underwent rapid development in the late 1910s, due to its importance as a "communication tool for the military and the intelligence community" during the First World War (Cheung and Brach 2011, 132-133). By the 1920s, "it became commonplace for families across the country to sit together after dinner around their radios in their living rooms, listening to their favourite programs" (Cheung and Brach 2011, 136). Radio was the "first truly *broadcast* medium," and it completely changed mass communications (Naughton 2012, 137, emphasis in the original). As Naughton (2012, 138) put it, "Radio created the world of mass media because it enabled broadcasters (and advertisers) to reach mass audiences for the first time. … And it enabled audiences of many millions of geographically dispersed listeners to share the same listening experience." From an interactivity viewpoint, this meant that a large group of geographically separated people could now access and interact with the same audio-based information *simultaneously*, which had not been possible with earlier forms of communication.

Motion pictures

Around the same time developments were being made in the transmission and broadcasting of sound, others were working on combining movement and images. The invention of motion pictures—also known as films, movies, and the photoplay—can be traced to Eadweard Muybridge's experiments in series photography in the 1870s, but the first commercial motion picture projector was only invented in the late 1890s by the Lumière brothers, Auguste and Louis (Cook and Sklar 2017). The addition of movement to photographic images brought visual communication one step closer to replicating real life. By combining movement (previously only afforded by descriptions in narratives) with visuals, motion pictures enabled viewers to have a richer experience than that offered by still photographs; for the first time viewers could literally see the world from another person's point of view. The photoplay had the ability to "[generate] a rich environment that modeled [sic] not so much the 'real world,' as the way the mind experienced the world" by using techniques that "simulated the movement of attention in the environment" (Biocca 2013, 100).

This reduced the cognitive effort required to interact with a still image, in the sense that it meant the viewer did not have to use their imagination to bring a scene to life—the photoplay provided the movement associated with the visual. Yet although the addition of movement to images provided a better quality simulation of real life than still images, the lack of sound and colour meant that motion pictures were still very much inferior to real life—the interactivity present was still not as rich as that in a real life experience. This did improve in the 1920s, when it became possible to record sound and motion pictures on the same film and their combined use become widespread (Cook and Sklar 2017). Later, in 1934, when the earliest full colour system in motion pictures was achieved (Grayson 2012), the marriage of photographic images with colour, movement, and sound, supplemented by the viewer's own imagination, offered a sensory experience that resembled real-life more closely than any other medium available at the time. These newer motion pictures were more immersive, but they lacked the immediacy and mass distribution capabilities of radio, and the synchronous communication afforded by the telephone. Motion pictures also required the viewer to cede all control, since they provided not only the narrative, but also the accompanying visuals, sound, and points-of-view.

Television

Television was essentially a combination of the radio and motion pictures. Introduced to the world in 1939, its widespread use did not occur until after the Second World War, where in the United States alone it reached over one million in 1948 and seven million by 1950 (Cheung and Brach 2011, 150-151). As a medium, television combined the best of both film and radio—merging moving images with sound and instantaneous mass distribution. It was also the most immersive communication medium by far—in terms of interactivity, geographically separated audiences could now interact simultaneously with the same information that was not only auditory (as with the radio), but visual as well (as with film).

However, as with radio and motion pictures, television was still not truly interactive, in the sense that it only allowed information to flow in one direction. Naughton (2012, 142) referred to television as "a 'push' medium," where "a relatively select band of producers (broadcasters) decide what content is to be created, create it and then push it down analogue or digital channels at audiences which are assumed to consist of essentially passive recipients". The audience's choice was limited to a set of pre-determined options (i.e. television channels), and access was restricted to specific times and locations by the producers or broadcasters of television channels. Additionally, the public's role as audience was fixed: "The viewer/listener was assumed to be incapable of, or uninterested in, creating content; and even if it turned out that s/he was capable of creative activity, there was no way in which anything s/he produced could have been published". (143)

This resulted in television being criticised because it encouraged passive viewing—giving rise to the term 'couch potato'—and was thus a killer of creativity (Naughton 2012, 145). But perhaps television, along with radio and print, was a 'push' medium because the available technology at the time simply did not allow for any other alternative. Following the arrival of computers and the Internet, it slowly became clear that "this passivity and apparent lack of creativity might have been more due to the absence of tools and publication opportunities than to intrinsic defects in human nature". (145)

Computers and the Internet

With each new development, technology gets closer to recreating the interactivity we experience in the real world. Early computers were mechanical rather than electronic, and were initially viewed as tools "to carry out computing and logic operations based on a set of instructions" (Cheung and Brach 2011, 167). The first electronic computer, the ENIAC (Electronic Numerical Integrator And Computer), was only completed in 1946 (Cheung and Brach 2011, 172), while the personal computer did not make its debut until the late 1970s (Cheung and Brach 2011, 267-268). With the advent of personal computers (or PCs), it became possible for the average person to interact with written information once more—the word processing software found on these computers allowed textual content to be edited. This was revolutionary *because* it simultaneously allowed not only permanency and legibility, but also ease of editing and dissemination (Levinson 2001).

As soon as technology allowed it, the same eventually happened with images, sound, and videos. Image editing software such as Photoshop surfaced as early as the late 1980s, though it remained largely the tool of professionals until the early 2000s. Likewise, digital sound recording and editing software were available since the 1980s, but did not enter mainstream usage until the MP3 file format was developed, and sound recording and editing apps (such as Apple's GarageBand) were developed for—and marketed to—personal users. The use of image editing and sound editing software by personal users was largely determined by the cost and processing power of personal computers. When personal computers became more powerful and affordable, and video-editing software became easier to use, video recording and editing by personal users also went mainstream.

The availability and affordability of computer software and hardware were not the only reasons the production of text, images, music, and videos became widespread. Although

Stafford observed that "[computer-based] communication has been called the 'fourth cognitive revolution' after speaking, writing, and printing" (1996, 92), the Internet also played a major role, providing a means for users to reach an audience, first in the form of personal websites and, later, in an increasing variety of formats: blogs, music sharing websites (e.g. Napster), and video sharing websites (e.g. YouTube), for example. This contributed to the proliferation of online content, as people began sharing images and information on the personal websites they had created. You might say that the huge leap in communications only really happened once the Internet was embraced by the masses in the mid-1990s.

For many, the Internet "holds out the tantalising promise of a quasi-mystical connectivity" because it gives us access to "a dizzying range of information" (Stafford 1996, 92). This connectivity arises from the networks we form when we communicate with others, and others communicate with us. Because the Internet supports the creation, revision and exchange of information, it gives us quick and easy access not only to information, but also to the network of people that supplies the information. In this context, we can see why many believe that interactivity is linked to the personal computer (and more recently, mobile technology devices), the Internet, and social media (Web 2.0 media). However, in computers and the Internet, as well as in earlier forms of communication media, interactivity still primarily occurs in two ways: firstly, between two or more people, and secondly, between a person and information.

Besides giving us the ability to create, revise, and exchange information with others, computers and the Internet have also made the cost of doing so pretty much negligible. Today, with nothing more than a computer (or smartphone) and an Internet connection, information can be created (and, fortunately or unfortunately, copied), then distributed cheaply, quickly, instantaneously to anyone and everyone who has access to the Internet. In the early days of the Internet, such communication was, arguably, mostly unidirectional. You could publish anything you wanted on your website for the world to see, but someone visiting your website still only saw "one unvarying answer to questions posed to it—namely, the words already written" (Levinson 2001, 18), even though hypertext links made answers easier to obtain (Levinson 2001, 137).

This changed after the dot-com crash in 2001, with the arrival of (what is now referred to as) Web 2.0. Web 2.0 was the term coined by Tim O'Reilly to distinguish the World Wide Web that existed before and after the dot-com crash (O'Reilly 2005). Web 2.0 is generally considered more interactive than Web 1.0, characterised by the two-way communication between creator and audience, a distinct characteristic of social media such as Facebook and Wikipedia. (Incidentally, Wikipedia defines social media as "computer-mediated tools that allow people to create, share or exchange information, ideas, and pictures/videos in virtual communities and networks".) With Web 2.0, information is not only created (or copied) and distributed cheaply, quickly, and instantaneously—it also allows for the originator of the information to interact directly with their audience, both synchronously and asynchronously, through features such as commenting on posts, wikis, etc.

Such features, commonly found in social media, might be the reason why social media is so voraciously embraced by Internet users—social media offer a means of communication that is closer to real-life communication than that offered by its predecessors. It addresses our frustrations with earlier modes of communication, as described here by Levinson (2001, 35):

> But there were miracles of communication, dreamed of by a species that saw the world in images not abstractions, yearned for by humans accustomed to an immediate response to a spoken word, that the printing press for all its extensional power could not deliver. The very humanity of these and other forms of pre-technological communication made their loss in the press, the tradeoff inherent in a global dissemination of abstract, delayed messages, all the more frustrating.

With social media, it is possible to give and receive responses immediately to visual, written, and oral communication. This was not possible before the existence of both the computer and the Internet. Another likely factor contributing to the rapid ascent of social media was discussed by Naughton (2012, 145), who pointed out that social media allows everyone to get "past the gatekeepers who controlled access to publication media," essentially making it possible for anyone to self-publish content they had produced themselves, be it as written text, images, music, dialogue, or videos. For much of the history of communication, the number of consumers of information has dramatically outweighed the number of producers (Levinson 2001). Excepting speech, which was and is "totally fluid in both directions" (117), and the telephone, which facilitated speech over distances, the imbalance between producers and consumers was significant. Many of the technologies that emerged over the years—books, radio, film, television—involved the production of information by a small group of producers for a comparatively large group of consumers. This was the case even when computers were first introduced, but as the size and cost of computers decreased, so did their accessibility and use increase, until they "could as inexpensively produce as receive data". (116-118)

Thus, with today's social media and touchscreen mobile devices, it can be argued that all the problems that previously existed in the various modes of communication have been solved. The production and consumption of information (in the form of text, images, sound, and video) can now occur both synchronously (where users do this in real-time) or asynchronously (where each user does this at a different time, to their convenience). Permanence and legibility are now not only paired with ease of editing and dissemination, there is also no longer any limit on the number of responses to any given piece of information.

However, the increased interest in virtual reality and immersive technologies suggest that we have not reached the end of the journey. There are instances where visual information or other sensory information would be more accurate in communicating an idea—how does one adequately describe a smell, for instance, so it can be recognised, if it has never been smelt by the reader before? This, then, is the main barrier we need to overcome if our goal is to achieve 'transparent communication', where we can accurately and completely communicate exactly what we are thinking and experiencing to others. Some headway is already being made in the development of ways to enable other forms of sensory experience via digital devices (Investigación y Desarrollo 2015), direct brain-to-brain communication via computers (Adler 2015; Bach 2015) and direct communication between the brain and a digital device (Jarosiewicz et al. 2015; Sellers, Ryan and Hauser 2014). The evolution of technology will almost certainly change how the interactivity between people, and between people and information; at the same time, understanding interactivity can help to find the best method of using technology to achieve transparent communication, and provides a different perspective on the debates involving technology, virtual reality, artificial intelligence, and communication.

The life cycle of communication media can be applied to interactivity

Having examined the history of communication using an interactivity lens, it would seem that the evolution of communication media parallelled the evolution of interactivity. It also became apparent that the information exchange we perform is driven by a desire to connect and communicate. Thus, it can be argued that the function of interactivity is to acquire or exchange information, and our attempts at improving communication are actually attempts to improve on how we accomplish this. This broader pursuit of the acquisition and exchange of information can be subdivided into the following four smaller goals:

» **Recording**. This involves giving information a physical form. We want this because it allows us to interact with and control information.

» **Distribution**. This involves spreading information as widely as possible. We want this because it promotes the exchange of thoughts and ideas with many other people, and this provides us benefits as both distributors and receivers.

» **Learning**. This involves acquiring new information, retaining it, and using it (which generally manifests as behavioural change). We want this because it allows us to verify what we know and to grow our knowledge base.

» **Control**. This involves having control over how we acquire, share, or exchange information (i.e. mediated or unmediated), as well as where we do this (i.e. in a virtual space or in real life), when we do this (i.e. synchronous or asynchronous), and with whom (i.e. individuals, small groups, large groups).[49] We want this because it gives us power over our interactions with the external world (i.e. that which is external to ourselves).

These four goals can be seen throughout the evolution of communication media, and occur as an almost-predictable order. Recording is typically the first goal of a communication medium and is the easiest to accomplish of the four goals. Once the information acquires a physical form, it is then possible to distribute it. Thus, the second goal is usually distribution. Historically, this involved either broadcasting, copying, or both. These two methods result in the widespread distribution of information and this facilitates the third goal—learning. Learning gives us power because it involves the use of knowledge to improve ourselves and our situation. Learning can also allow us to identify ways to control the world around us. Control[50] is usually the last goal, mainly because it is the most difficult to achieve. This is because it must be preceded by enough learning to produce the necessary innovation required for a significant technological leap—to understand this, one only needs to compare the differences between pen-and-paper and Gutenberg's printing press in terms of their mechanical and technological complexity. Of course, in reality these goals do not occur in a neat or organised fashion, but rather as a series of overlapping cycles, propelled along by the agendas of various individuals, available materials and technology, as well as social and cultural contexts at large.

If we consider these goals from an interactivity-based perspective, it would seem that we are still in the learning stage of the cycle. As in, we are still learning about interactivity—how it works, how to use it, how to replicate it, etc.—and are in the throes of developing control over it.

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[49] This desire to have more control over how we interact with each other (and with the world around us) might partly explain why we are so enamoured with the idea of simulations that perfectly replicate real life (see page 99 for the discussion on interactivity and simulations).

[50] Arguably, the ultimate manifestation of this final goal might be a perfectly transparent medium that lets us communicate using nothing but our minds, when we want to, where we want to, and with whom we want to.

Interaction, interface, and interactivity

This section examines the design disciplines that have emerged as a result of new technologies. A version of this section has been presented as a paper titled "Interaction, Interface and Interactivity" at the 2015 ACUADS conference in Melbourne, Australia.

The previous section, "Interactivity and communication", showed how the introduction of computers resulted in new ways of interacting with information, people, and spaces. As computer technology grew more advanced and humans interacted with computers in more complex ways, greater care had to be taken in the design of computer systems. A number of design disciplines emerged in response to this. This section looks at some of these design disciplines, specifically interface design, user interface design, interaction design, experience design, user experience design and interactive design. To understand the complex relationships between these various design disciplines, it is useful to know the history and origin of both the term and the discipline. The first half of this section looks briefly at this to clarify the distinctions between them, while the latter half looks at the interactivity in each of the six design disciplines listed above, and how interactivity connects them together. It also raises questions about how we view interactivity in these disciplines.

Interface design and user interface design

Early interface designs were focused on achieving technical function, but over time, the focus began to shift "from efficiency and performance in relation to solving work-related tasks to user satisfaction with and experience of the product" and technology-based products went from being functional and utilitarian tools to coveted fashion accessories (Jensen 2013, 184). Two factors contributed to this: fixed-program computers were replaced by stored-program computers and computers started being used *en masse* by the general public. These same two factors are also tied to the origin of the terms 'interface' and 'user interface' (Grudin 1990).

The first computers were fixed-program computers that could only perform a single task and had to be physically rewired for a different task (O'Regan 2008). The interface was the boundary between the programmer and the computer, and since the first computer users were equipped to make any necessary changes themselves, there was no need to distinguish between the user and the programmer (Grudin 1990). Little thought was spared for the quality of the interface design.

Stored-program computers were introduced that could be instructed to do several different tasks without having to be physically rewired each time (O'Regan 2008). This eventually led to the introduction of interactive terminals, which necessitated changes in the user interface as the number of users who were not programmers increased (Grudin 1990, 263). As the user interface established itself in human-computer interaction (HCI) research, the interactive capability of terminals together with the introduction of visual displays gradually brought about a need to address more than just the perceptual, motor and cognitive issues. The increasing use of colour, graphics, windows, and other capabilities saw graphic artists being brought in "with their different approaches to design and evaluation". (Grudin 1990, 264)

Arguably, it is at this point that user interface design as we know it today was born. Bridging the gap between human-computer interaction and graphic design, today's user interface design "brings together concepts from interaction design, visual design, and information architecture" (U.S. Department of Health & Human Services 2014).

Interaction design (IxD)

When Bill Moggridge gave the first conference presentation on interaction design in 1984, he saw it as "the equivalent of industrial design but in software rather than three-dimensional objects", "dedicated to creating imaginative and attractive solutions in a virtual world, where one could design behaviors [sic], animations, and sounds as well as shapes" (Moggridge 2007, 14). The early years of interaction design were decidedly interdisciplinary, since the absence of formal interaction design education meant that designers from various backgrounds needed to work together. Moggridge's first interaction design team included an information designer, a graphic designer, and an industrial designer (Moggridge 2007, 14). This mixing of disciplines echoed the postmodernist design thinking that dominated during the late 20th century, in particular its penchant for eclecticism, collage and pastiche. It was also a precursor to the major paradigm shift that saw the boundaries between design disciplines become increasingly blurred and paved the way for new design disciplines such as experience design.

Those working amidst these blurred boundaries began to shift their focus: from working within their defined discipline to working toward "designing things so that they're right for people" (Smith in Moggridge 2007, xiii). As Smith explained, it is no longer enough to build interactive systems that "focus on the technology that makes them possible", consideration must also be made toward "the interfaces that allow people to use them" since "people … and their goals are the point of our systems, and we must design for them" (Moggridge 2007, xii). Thus, in interaction design it is not enough to simply aggregate the individual design outcomes from each discipline. Interaction design requires an approach to the design of interactive systems that is both multidisciplinary and interdisciplinary. It should consider not only how they look and behave, but also the "*quality*" of how they interact with users (Moggridge 2007, xvi, emphasis in the original).

Although Moggridge originally saw interaction design functioning within "a virtual world" and "in software" (Moggridge 2007, 14), the discipline has evolved. Its evolution is in part dictated by its name—while Moggridge originally used 'interaction' in reference to human-computer interaction (HCI), others see 'interaction' as referring to "the way in which we interact with products and systems in general" (Hallnäs 2011, 75). This shift from an HCI-based view to a more generalised one resulted in a new approach to design—designing with the way one might interact with the object in mind, rather than designing the object itself. Such an approach inevitably affects (and sometimes becomes) the object's design. As the concept of "designing the acts that define the intended use of things and systems" started to spread to other design disciplines, interaction design began to include products other than "computer interfaces and computational devices" (Hallnäs 2011, 75). At the same time, the growth and evolution of interaction design also produced offshoots in the form of an array of new disciplines such as information design, experience design, media design, amongst others (Thomassen and Ozcan 2010, 850).

Experience design (XD) and user experience design (UXD or UED)

Experience design has arguably been around since experiences were recognised as such

(Shedroff 2001, 2). As a discipline, however, it is relatively new and its origins are hazy. One of the earliest references to experience design can be found in a 1998 *Harvard Business Review* article titled "Welcome to the Experience Economy", where authors Pine II and Gilmore wrote that they "expect experience design will become as much a business art as product design and process design are today" (102). The newness of experience design as a discipline means its definition is still open to interpretation and negotiation (Jensen 2013; Shedroff 2001). For better or worse, a formal definition is lacking, an issue Jensen (2013) tried to address. He offered a comprehensive and detailed look at "the concepts and fields of user experience, experience design and user-experience design in order to account for their origins and meaning, to outline their interaction with one another and their interaction with other fields and concepts and to find a common understanding and definition" (Jensen 2013, 183).

One major point of contention when it comes to the definition of experience design is whether it is simply "a field for digital media" or whether it more broadly refers to the collective array of design fields involved in the design of an experience (Shedroff 2001, 2). Despite the lack of clarity surrounding its definition, experience design has come into its own. This can be attributed, in large part, to the emergence of what Hassenzahl (2013) called "a version of the Experience Society". The 20th century was focused on products, wrote Oppelaar et al. (2008, cited in Jensen 2013, 180), while the 21st century is focused on experiences. This emphasis on experiences is likely a manifestion of the 21st century postmaterialism[51] that lies at the core of the Experience Society, which Hassenzahl (2013) depicted as favouring "deceleration instead of acceleration, less instead of more, uniqueness instead of standardisation, concentration instead of diversion, and making instead of consuming". Thus, Hassenzahl wrote, "The challenge of designing interactive products for the post-materialist is to bring the resulting experience to the fore—to design the experience before the product." Instead of modernism's 'form follows function' or postmodernism's 'form over function', the underlying principle of experience design is 'form and function follow experience'. Hassenzahl described this as, "Experience Design wants the Why, What and How to chime together, but with the Why, the needs and emotions, setting the tone."

Despite sharing the word 'experience', the term 'user experience' (UX) started out differently—as a "buzzword in the field human-computer interaction (HCI) and interaction design" (Hassenzahl and Tractinsky 2006, 91). It has since grown and evolved to become a design

[51] The online version of Encyclopædia Britannica defines postmaterialism as a "value orientation that emphasizes self-expression and quality of life over economic and physical security".

discipline in its own right. Peter Merholz (1998), founding partner of experience design consultancy Adaptive Path, looked at the origin of the term 'user experience', tracing it to a 1995 CHI proceedings paper by user-centred design proponent Donald Norman, who co-wrote it with Apple colleagues Jim Miller and Austin Henderson. Merholz subsequently emailed Norman about his use of the term, whereupon Norman replied:

> I invented the term because I thought Human Interface and usability were too narrow: I wanted to cover all aspects of the person's experience with a system, including industrial design, graphics, the interface, the physical interaction, and the manual.
>
> Since then, the term has spread widely, so much so that it is starting to lose its meaning. (Merholz 1998)

The need for clarification with regard to meaning is just as applicable today. Interestingly, despite experience design emerging from a move to combine multiple—digital and non-digital—design disciplines as part of a holistic approach and the term 'user experience' originating from HCI and interaction design, the general consensus among academics and industry seems to be that user experience design is a subset of experience design (Jensen 2013; Paluch 2006). More precisely, experience design aims to create a holistic experience through the design of products, services and environments, focusing "especially on the interaction models and architecture" (Jensen 2013, 201), while user experience design specifically applies to computer-related products (Paluch 2006). Jensen (2013, 202) further clarified this, stating, "user experience and user-experience design are linked exclusively to interactive digital media or technologies".

Interactive design and interactivity design

The term 'interactive' has been bandied about for a while now, and features in one of the more recent contributions to the terminology mishmash: interactive design. Interactive design has been used as an abbreviation of interactive media design, which in turn, refers to the design of digital media that is interactive such as websites and video games (as opposed to digital media that is not, like e-books and MP3s). Interactive design has also been used interchangeably with interactivity design (Crawford 2002). Even tertiary institutions teaching interactive design use the term 'interactive design' differently (e.g. Interactive design 2014a; Interactive design and media 2014; Interactive design 2014b; School of Interactive Design 2014; University of Lincoln 2014).

Interactive design is also sometimes confused with interaction design. A Google search for 'interactive design' generates approximately 183,000,000 results and funnily enough, the first result is the Wikipedia entry for 'Interaction design'. (It is followed by the Wikipedia entry for 'Interactive design' which, incidentally, contains a section titled "Interactive Design Compared to Interaction Design".) One source of the confusion comes from the use of 'interactive' by "ad agencies and other traditional (pre-online) entities as they branched into multimedia and eventually the web" (see the discussion by Crumlish 2010; Korman 2010; Silvers 2010). Within industry, it seems, interactive design refers to the design of interactive digital media including, but not limited to, websites, video games and mobile applications (see Capricorn Digital 2014; HOW Design Live 2014; Moré 2014).

Mapping relationships between design disciplines

Some have tried to map the relationships between various design disciplines (Garrett 2003; Saffer 2009). Garrett's (2003, 33) model of the elements of user experience consists of five planes (surface, skeleton, structure, scope and strategy) and features visual design on the surface plane; interface design, information design and navigation design on the skeleton plane; and interaction design and information architecture on the structure plane. Saffer (2009) mapped the disciplines of user experience design using a complex Venn diagram.

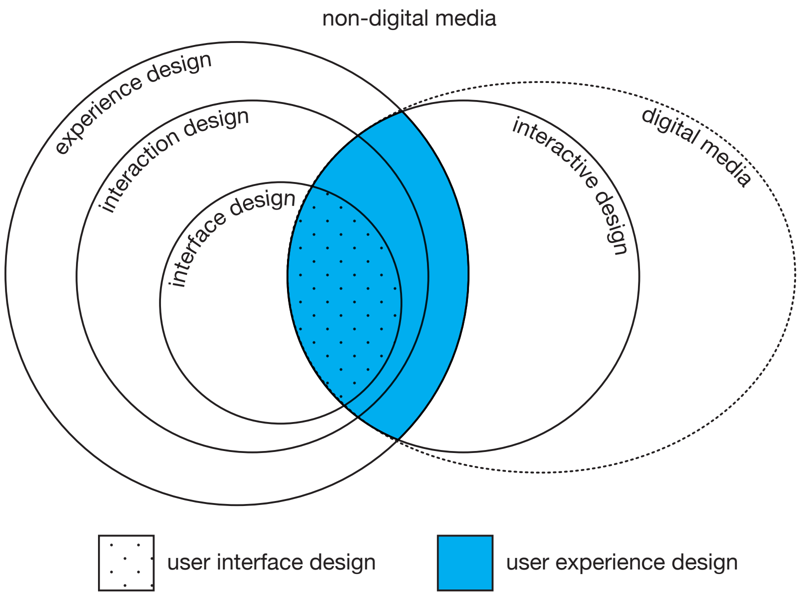

Figure 2: Proposed map of relationships between design disciplines

Figure 2 shows a proposed map of the relationships between the six design disciplines discussed in this paper. As in Saffer (2009), a Venn diagram style is used. The map shows the overlaps between the six design disciplines themselves in both digital and non-digital contexts. As shown, although interface design and interaction design emerged from the field of human-computer interaction, today these design disciplines have expanded to include the design of non-digital interfaces and interactions. As a discipline, experience design can be said to be all-encompassing, being both multidisciplinary and interdisciplinary. However, user interface design and user experience design, as well as interactive design, are generally seen as applying only to digital media.

Design disciplines and interactivity

Other than their relatively short existence and their rapid, ongoing evolution, these design disciplines share another thing in common: interactivity. In non-digital and digital media alike, each of these design disciplines incorporate interactivity in their design outcomes. The earlier assumption that all experiences are aesthetic experiences, together with the contemporary focus on acquiring experiences over products (see Oppelaar et al. 2008 on page 124), all serve to highlight the importance of experience design. This is especially because experience design is specifically about designing the overall experience, or, to repeat what Hassenzahl (2013) said, "Experience Design wants the Why, What and How to chime together, but with the Why, the needs and emotions, setting the tone".

Interactivity and the search for the perfect simulation

The invention of the computer changed the ways in which we interacted with the world around us, and with each other. Of these, one of the most significant offerings that computers have given us is the ability to create virtual worlds, or simulations of worlds (including the one we live in). Because computers enabled the creation of these virtual environments[52], we are now able to vicariously experience things that were previously off-limits (defying gravity and death, for example)—both from a third-person perspective and, as technology grows more sophisticated, from a first-person perspective. This is a completely novel experience. Prior to this, escaping the basic laws of this world could only be accomplished using one's imagination. The introduction of computer-generated virtual environments has given us access to a whole range of new and previously only ever imaginable possibilities. We can now experience the adrenaline rush without exposing ourselves to life-threatening danger, have greater control over what we do and what we look like, and experience life in imaginary worlds when we are awake. With computer technology, our dreams can now become reality (or virtual reality, as it were).

As so-called interactive technologies and interactive media give us greater control over our actions and our appearance, over what things look like and how they work, and over risk, this newfound freedom is also eliciting concern that "digital spaces were subtended by a strong desire for control over the messiness of bodies and the unruliness of the physical world" (Munster 2006, 2). We can see this desire for control being played out in the evolution of communication media described in "Interactivity and communication" (page 76). One could argue that this is the reason we seek to perfectly simulate the real world. It is why we have become so enamoured with the increasing interactivity that each new generation of technology

[52] This often took the form of computer games.

offers. Yet one could also argue that our fascination with simulation is simply the result of our innate desire to explore—to see how far we can go in pushing our personal boundaries and that of the world around us. Or perhaps it is neither of these. Frank Biocca (2013) proposed a different line of thinking: that new mediums emerge not to reproduce the real world, but to simulate the world inside our minds; he called this "mental simulation". He also argued that motion pictures' ability to model "the way the mind experienced the world" made it possible for us to literally see the world from another person's perspective (100). Ryan (2001) had a similar view, suggesting that simulation is a physical and visual manifestation of narrative.

With this in mind, the rest of this section examines the relationship between narratives and simulations, and how these relate to immersion and interactivity. In "Narratives and simulations," two opposing interpretations of narratives and simulations are examined. "Presence and immersion" discusses the concepts of narrative and simulation alongside three other complex and overlapping subjects—technology, presence and immersion—and seeks to further clarify the relationships between each of these. "Experiences and interactivity" concludes with a discussion on experience and interactivity, and how these are influenced by narratives, simulations, immersion, and presence.

Narratives and simulations

If we assume that the evolution of new media is fuelled by a desire to simulate what is in our minds, then simulations are actually narratives in physical form, and we must consider the role of the narrative when thinking about interactivity. There is abundant evidence that humans are, and have always been, drawn to narratives. The president of Pixar Animation and Disney Animation, Ed Catmull, (and arguably all of Hollywood) certainly knew this to be true—Catmull cited "Story Is King" as one of Pixar's guiding principles during the creation of Pixar's first film, *Toy Story*, observing also that everyone in the movie industry "repeated some version of this mantra" (Catmull and Wallace 2014, 79). According to Zipes (2012, 2), storytelling has been used by people to "learn about themselves and the worlds that they inhabited", "to mark an occasion, set an example, warn about danger, procure food, or explain what seemed inexplicable" and "to communicate knowledge and experience in social contexts". In other words, narratives exist primarily for us to *communicate ideas to and with each other*.

Today, digital technologies have dramatically improved the ways we do this, especially in comparison to the rudimentary communication methods used by the ancient Greeks and medieval scribes described in "Interactivity and communication". These technologies give us more control over how we relay the contents of our minds to others, while also making it quicker and easier for us to do so. At the same time, older forms of media continue to thrive, even as they have to adapt and change to do so. This suggests that, in the context of communication, technology is nothing more than an optional extra; it facilitates communication, but it is not the point or the focus of it.

This is particularly apparent in Biocca's observation that speech and movement were "used to simulate narrative worlds: physical spaces, social interactions, and mental states of characters" (2013, 97) in the absence of any kind of technology, not even paper. A well-executed narrative can successfully transport the audience (i.e. viewers, listeners, or players) into the world of an idea, or what Herman (2002) referred to as a *storyworld*. Although low-tech by today's standards, speech and movement were—and still are—effective tools in storytelling. Over time, these low-tech tools have been supplemented with written language, visual communication (including drawing, painting, sculpture), and media technologies. These newer tools have enabled our narratives to become more complex and sophisticated.

While Biocca (2013, 102) believed that narratives are a form of simulation, Frasca distinguished between traditional media and new media, arguing that "unlike traditional media, video games are not just based on representation but on an alternative semiotical structure known as simulation" (2003, 221-222). Frasca proposed that there are differences between representations, narratives and simulations. He suggested that a photograph of an aeroplane is a representation of the real thing, in that it "will tell us information about its shape and color [sic], but it will not fly or crash when manipulated". A film of an aeroplane landing, however, is a narrative; it can be interpreted "in different ways" by a viewer, but the viewer "cannot manipulate it and influence how the plane will land since film sequences are fixed and unalterable". A flight simulator, on the other hand, is a simulation because it "allows the player to perform actions that will modify the behavior [sic] of the system in a way that is similar to the behavior [sic] of the actual plane". Thus, he concluded that "narrative is a form of structuring representation" and similarly, "video games are … a particular way of structuring simulation". (223-224)

Frasca used the terms *ludus* and *paidia* (which he adopted from Roger Caillois) to highlight that it is not possible to control outcomes in narratives and traditional media while, by contrast, it is possible to control outcomes in simulations. He described narratives as taking a *ludus* approach, and simulations as taking a *paidia* approach. *Ludus* is used to describe “games with social rules (chess, soccer, poker)” (i.e. those with specific, controlled outcomes) and *paidia* is used to describe “the form of play present in early children (construction kits, games of make-believe, kinetic play)” (i.e. those with undetermined, non-specific outcomes, or what is commonly termed in education today as free play). (229) The way Frasca distinguished simulations from narratives appears to be tied to two factors: (1) the audience’s ability to manipulate or control the simulation; and (2) the number of possible outcomes. If simulations are defined by co-authorship and variable outcomes, this would automatically qualify video games as simulations, and disqualify narratives at the same time, because in narratives, the author/artist has sole control and the audience is limited to a single viewpoint (the author’s/artist’s), and the outcome is fixed.

This view is reflected in the four different “ideological levels” Frasca used to differentiate between narratives and simulations. The first level deals with representation rules (i.e. how objects, characters, settings, etc. are represented) and is shared by both narratives and simulations. The second level is concerned with manipulation rules (i.e. possibilities, or what you are able to do), the third level with goal rules (i.e. what you must do to win), and the fourth level with meta-rules (i.e. rules about “how rules can be changed”). Frasca omitted applying the latter three levels to narratives, suggesting that he believed they could only be applied to simulations. (232)

The opposing views of Frasca and Biocca are both of value. On the one hand, Biocca’s approach is more broadly applicable, given that representation may not always be the point of a narrative, even though verbal description or visual depiction can function as representation. In other words, if the purpose of a narrative is to enable the simulation of a storyworld[53], then representation is actually a means of generating and maintaining the simulation without the use of technology. Thus, language-based narratives use spoken or written words to describe the simulation (what it looked like and how it worked), while visual-based and movement-based narratives use visuals and movement respectively to *illustrate* or *enact* the simulation. The notion that language-based narratives are a form of simulation is supported by evidence that showed readers “construct mental simulations of events when reading stories”:

> For example, changes in the objects a character interacted with (e.g., “pulled a light

[53] See *The Lord of The Rings* trilogy by J.R.R. Tolkien for examples of this. For a specific example, see pages 220-221 in *The Fellowship of the Ring* (1991, hardcover, published HarperCollins).

> cord") were associated with increases in a region in the frontal lobes known to be important for controlling grasping motions. Changes in characters' locations (e.g., "went through the front door into the kitchen") were associated with increases in regions in the temporal lobes that are selectively activate when people view pictures of spatial scenes." (Everding 2009)

On the other hand, thinking about Frasca's views can help us deepen our understanding of narratives and simulations. Consider Frasca's argument that simulations should enable the audience or player to have control over what happens in the simulation, for instance. Video game simulations offer players greater control over the storyline, but they offer limited control over the appearance of the simulation (even if some games have a greater capacity for modification than others). Text-based narrative simulations, however, generally offer readers little to no control over the storyline, but allow them almost complete control over the appearance of the simulation, since readers use their imagination to generate their own visuals in response to the text descriptions. With image-based narratives (such as Leonardo da Vinci's *The Last Supper*), viewers have no control over the appearance, but have more control over the storyline; they are free to interpret the story behind the various disciples' facial expressions and the events leading up to the depicted scene. In film-based narratives, viewers may have no control over the storyline or the visuals, but they can have a vivid visual experience from a first-person viewpoint—a quality used to maximum effect in the film *Being John Malkovich*[54].

Thus, to disqualify narratives on the basis of the issue of control is to overlook an important point: that this may have more to do with context than ideology. The limitations of traditional narratives and visuals—lack of control and fixed outcomes—that disqualify them from being considered simulations are largely due to the limitations of technology at the time narratives were first conceived, not necessarily because of a conscious decision by authors and artists to withhold control from their audience. Subsequent efforts to break the constraints of traditional narratives (e.g. the original *Dungeons & Dragons*[55] from 1974 and the popular *Choose Your Own Adventure* series of books from the 1980s) are prime examples of authors attempting to address this issue.

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[54] *Being John Malkovich* is a 1999 film in which various characters use a portal to enter actor John Malkovich's mind, thus allowing them the ability to observe and sense what he does. Interestingly, in the latter part of the film, one character finds he is able to control Malkovich's actions from inside the portal.

[55] *Dungeons & Dragons* is an open-ended role-playing game. The game takes place in the form of a story, the outcome of which is determined by a set of rulebooks, dice, and the decisions of individual, real human players (which affect their characters' abilities and actions).

Frasca's four ideological levels can also be used to challenge our perceptions of narratives, by applying the last three levels of Frasca's four ideological levels to narratives. This is not inconceivable—after all, a narrative can contain manipulation rules (i.e. what is possible in the storyworld) and goal rules (i.e. what the protagonist must do to overcome any conflict that arises), and sometimes, even meta-rules (i.e. that which changes the initial premise and setting of the storyworld, or the goals of the protagonist). Recent cinematic narratives such as *Inception*, *Transcendence*, and *Doctor Strange* all push the limits of the traditional narrative because they contain manipulation rules, goal rules, and meta-rules.

From the above, it is clear that narratives and simulations have similarities, but they also have differences. Narratives and simulations are similar in that they both serve a communicative function. They can both be used to learn and teach new information, to speculate about what might happen in the future, to recount what has already happened in the past, and to transfer information from ourselves to others and vice versa. However, the obvious limitation with both narratives and simulations is that they tend to be mediated experiences. In other words, they primarily communicate experiential information through media. On the other hand, there are differences in the way narratives and simulations perform their communicative function. Text-based narratives communicate by providing the base materials from which readers have to first construct their own visuals via their imagination and then use these to imagine what the experience would be like. Simulations provide ready-made visuals that allow users (or players) to actually experience the narrative firsthand, albeit in a digital virtual environment.

It is the differences between narratives and simulations that determine their suitability and efficacy in communication. Moreover, this is more dependent on context and purpose than on any particular inherent characteristics of narratives or simulations. With text-based narratives, the reader has to supply the visual information for the narrative using his or her imagination. This means that the quality of the visual and experiential information in a narrative experience[56] is likely to vary depending on the reader's imaginative capabilities. In situations where a reader's lacklustre imagination has a negligible impact on the quality of his or her comprehension or experience, this is a non-issue. With fiction novels (especially those with significant amounts of descriptive language), however, a vivid imagination is not only desirable—it is a necessity. In this context, the cognitive load[57] can be greater with narratives.

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56 See page 203 for more on narrative experience.

57 See page 144 for an explanation of cognitive load.

Conversely, with simulations people do not need to generate their own imagery using their imagination. This frees them up to use other cognitive functions and ensures consistency in the visual and auditory information they receive, since those engaging in the same simulation experience the same visual and auditory content. An excellent example of this[58] is the Hayden Planetarium Space Show, *Dark Universe*, created by the American Museum of Natural History, the Frederick Phineas and Sandra Priest Rose Center for Earth and Space, and the Hayden Planetarium[59]. Screened in the Hayden Planetarium, *Dark Universe* provides a 360-degree view of "exquisite renderings of enigmatic cosmic phenomena, seminal scientific instruments, and spectacular scenes in deep space" (American Museum of Natural History 2015). Simulation was the ideal communication format for *Dark Universe* because the scientific data used to generate the simulation was so complex and detailed that it would have been too difficult for the average person to generate the requisite visuals from a written or verbal narrative using only their imagination. Thus, simulations can help to alleviate the cognitive load because they do not require people to generate their own visual and audio content.

The ability of simulations to visualise complex data can be compared to the ability of written communication to record ideas on paper. Each of these help to reduce cognitive load by giving physical form to an abstract and/or complex concept, reducing the load required to hold it in one's working memory or to generate any requisite mental images. This frees the mind up to focus on other things (like analysis, critique, or theorising) and allows the concept to be scrutinised from a distance.

Presence and immersion

Narratives and simulations all rely on media to function. However, this reliance on media is a barrier to achieving direct experience. Presence is seen by many as a way to remove this barrier. Presence can be said to refer to feeling as though one were actually situated within a virtual environment, as opposed to being a distanced viewer or being situated in a real-world environment[60] (Mestre and Vercher 2011, 94). McMahan (2003, 72) explained that the current

58 Admittedly, *Dark Universe* cannot strictly be classified as a simulation since one can only participate as a viewer, and does not have any control over the content or the system's behaviour. However, it can be argued that the show does, to an extent, simulate being in space—if only in a spacecraft that is manned and piloted by someone other than oneself.

59 See http://www.amnh.org/exhibitions/space-show/space-show-dark-universe.

60 Mestre and Vercher (2011, 94) also recommended looking at Held and Durlach, 1992; Heeter, 1992; Sheridan, 1992; Lombard and Ditton, 1997; Biocca, 1997.

usage of presence is derived from the term 'telepresence' and referred to Steuer's discussion of the two terms. Steuer (1992, 75-76) distinguished between presence and telepresence, where presence is "defined as the sense of being in an environment" and telepresence is "defined as the experience of presence in an environment by means of a communication medium". The former is used to refer to "*natural* perception", and the latter to "*mediated* perception" (Steuer 1992, 76, emphasis in the original). McMahan also offered Lombard and Ditton's definition—possibly as a more concise alternative—where presence is "the artificial sense that a user has in a virtual environment that the environment is unmediated" (McMahan 2003, 72).

Discussions about presence inevitably lead to a discussion about immersion because the two are not always seen as distinct concepts. McMahan observed that "the term presence is often used synonymously with *immersion*" (2003, 70, emphasis in the original), while Lombard and Ditton (1997) declared that presence can result from "perceptual or psychological immersion". The confusion between immersion and presence is understandable if we define immersion as a subjective assessment based on our own personal perception of a simulated or virtual (or mediated) environment, as McMahan (2003), Witmer and Singer (1998, cited in Mestre and Vercher 2011), and Ermi and Mäyrä (2007) did. McMahan proffered Janet Murray's definition of immersion as the "most accepted definition":

> The experience of being transported to an elaborately simulated place is pleasurable in itself, regardless of the fantasy content. We refer to this experience as immersion. *Immersion* is a metaphorical term derived from the physical experience of being submerged in water. (2003, 68, emphasis in the original)

Mestre and Vercher (2011, 94) credited Witmer and Singer with defining immersion as "a psychological state characterised by the fact of perceiving oneself 'in' an environment (virtual) that provides a continuous flow of information". Ermi and Mäyrä (2007) observed that "the concept of immersion is widely used in discussing digital games and gameplay experiences" by players, designers and researchers alike, but often this is done "in an unspecified or vague way without clearly stating to what kind of experiences or phenomena it actually refers" (40). Ermi and Mäyrä (2007) interviewed Finnish parents of children who actively played digital games, and found that the parents believed that games were immersive because of the quality and realism of the graphics and audio. The children themselves "acknowledged often becoming immersed in games, but in different ways than in literature or cinema". They reported being more emotionally immersed in books and films than in games while also admitting that they also found games immersive, but in a different way. They considered the most immersive aspect of games to be interactivity, referring to players' ability to "make decisions, take actions, and have an effect on gameplay". (Ermi and Mäyrä 2007, 42)

On the other hand, there are a number of scholars who viewed presence and immersion as separate and distinct concepts (Mestre and Vercher 2011). Slater, for example, saw immersion as the result of the objective appraisal of a system and defined it as referring to "capabilities of the system to isolate the user from the real world, and provide rich, multisensory and coherent information" (Slater 2003, cited in Mestre and Vercher 2011, 93). Following on from this, if immersion is defined as "what technology allows, from an objective point of view" and presence as "the subjective response to immersion" (Mestre and Vercher 2011, 94), then presence can be said to be the goal of immersion.

This notion is nothing new. As Biocca observed, the pursuit of presence through the use of immersive technologies has been around for years—"Immersive technologies have long been presented as sources of powerful illusion in utopian or dystopian hues in science fiction: for example, Orwell's 'feelies,' Bradbury's 'televisors,' the Star Trek 'holodeck' and Gibson's 'simstim.'" He even went so far as to suggest that this "has been the goal of virtual environment engineering since its birth (Sutherland, 1965)". The pursuit of this goal can also be described as the search for a perfect simulation, where a perfect simulation is characterised by "high levels of presence", in which "physical, fictional, and imaginal become 'almost' indistinguishable". (Biocca 2013, 114) Therefore, a perfect simulation—the holy grail of simulations—should be exactly like a real-life experience, such that one is indistinguishable from the other, and it is impossible to tell where one ends and the other begins.

Experiences and interactivity

Biocca and Steuer both suggested that instead of viewing media, narratives, and simulations as communication tools, we should view them as settings in which experiences occur. Biocca (2013) described it as:

> Indeed, when engaged with a compelling medium or story, we may sometimes experience a sense of being transported to a different place (Gerrig, 1993), so much so we seem to be inside the mediated space. For a brief moment or longer, we may forget that the experiences flashing across a screen (the artificially generated light arrays) are being presented through technology. At some moment we become aware just of the experience, and not the medium. (101)

Similarly, Steuer (1992) advocated that mediated communications be viewed as mediated environments that are created for people to experience rather than as channels through which information is sent and received (77-78). In view of this, he rejected popular definitions of virtual reality[61] that referred to its technological characteristics or elements[62] (74) and proposed that virtual reality be defined in terms of human experience instead of hardware (75). This underlies his definition of a virtual reality as "a real or simulated environment in which a perceiver experiences telepresence" (76-77).

In addition to media, narratives, and simulations, Biocca also discussed how immersion and presence can also be viewed in terms of experience. Concerning immersion, he stated that a well-executed narrative can result in an immersive experience, since immersion results from "*moments when a narrative is most powerfully connected to the user*, moments that users often remember, moments when the distinction between a mediated experience and a direct experience becomes blurred" (101, emphasis in the original). In so doing, he drew a connection between narratives, immersion, and experience. He also emphasised that immersion can be achieved with narratives regardless of whether the medium used is interactive, virtual reality, or otherwise:

> Most researchers in this community acknowledge that that experience of presence predates any advanced media. This acknowledgment is bound up with the theoretical conundrum we call the *book problem*. A theory of presence derived for work in advanced media must also be able to explain how the sensation of 'being there' can occur not just in a virtual reality system, but with any medium, including much older noniconic, 'low-tech' media such as books (e.g., Gerrig, 1993). (102, emphasis in the original)

As for presence, he pointed out that the research into presence is not just about explaining the concept of presence, but about how "to better control presence, to more consistently and reliably evoke the experience of presence in the user" (102). Recent efforts to accomplish this have tended to focus on using media technologies such as virtual reality because such technologies allow the user to experience a virtual world as though they were actually present within it. In relation to this, Biocca said, "The key to optimizing human performance and experience in these 'mind machines' may lie in understanding how the machine interacts with the mind to create this deep sense of what has come to be called *presence*" (102-103, emphasis in the original). However, he also declared that "full perceptual immersion in a narrative illusion, an absolutely 'transparent' medium, has not yet been achieved" (114).

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[61] This is particularly noteworthy considering the flurry of activity that is occurring in relation to virtual reality and video games (particularly that surrounding the Oculus Rift virtual reality headset, see page 164).

[62] This tendency to focus on technological characteristics seems to happen in other media formats as well.

Learning

> Knowledge acquisition is not pursuant to sensory perception; rather, it is a process of awareness that can take place either by means of emotional or physical (cathartic) transformation or by means of conscious reflection. In any case, it is always based on action.
>
> (Kwastek 2013, 261)

This section is divided into three main parts. “Learning and education” provides an overview of the different definitions of learning, and explores how these have influenced the perceptions and approaches to learning and education over time. “Learning and literacy” examines the definitions and types of literacy, and also discusses the dichotomy between literacy and visual literacy. “Learning and technology” looks at the main issues relating to the use of technology in education.

Learning and education

Learning is usually thought of in the context of formal education, however learning can and does occur outside of formal education as well. Formal education, as we know it today, can be traced to the invention of the printing press. When Gutenberg invented the printing press, it led to the widespread use of books and other printed materials, which in turn necessitated the rise of public education because people had to learn how to read in order to decipher them (Levinson 2001, 31). With the Industrial Age, formal education was also used to prepare the young for the workforce, which "in the early part of the twentieth century tended to focus on the acquisition of basic skills and content knowledge, like reading, writing, calculation, history or science"[63] (Institute of Play 2015). Accordingly, the primary goal of formal education was "to *facilitate intentional learning*, in order to accomplish many goals that would take much longer without instruction" (Gagné et al. 2005, 1, emphasis in the original). For a better understanding of these different perspectives, it is necessary to consider the definitions of learning.

Definitions of learning

The Merriam-Webster dictionary lists three definitions under 'learning': (1) the act or experience of one that learns; (2) knowledge or skill acquired by instruction or study; and (3) modification of a behavioral tendency by experience (as exposure to conditioning). A lengthier combination of all three definitions was also given, where 'learning' is defined as "the activity or process of gaining knowledge or skill by studying, practicing, being taught, or experiencing something". So if we consider life to be a collection of experiences, then we might say that we live in a constant state of learning. "As human beings we perceive and process information

[63] Chomsky criticised this view that the main purpose of education is to prepare the young for future entry into the workforce, and methods used to indoctrinate them for this purpose. (lwf 2012)

every waking minute," wrote Gagné et al. (2005, 3). "Some of this information is filtered out and some is incorporated into what we know and remember." This section on learning starts by examining learning using the three Merriam-Webster definitions and concludes by exploring the changes in learning and education that have resulted from a blurring of the divide between these three definitions.

Learning is an experience

The first Merriam-Webster definition describes the act of learning itself as an experience. This definition highlights that the relationship between learning and experience is interdependent. Experiences result in learning, but the act of learning itself also constitutes an experience, both in the contexts of traditional formal education and less orthodox avenues that involve learning from personal experiences. This interpretation of learning also suggests that the learner is an active participant in the experience of learning. As Pine and Boy (1977, cited in Boy and Pine 1999, 221) stated, "Learning is an experience that occurs inside the learner and is activated by the learner."

Learning from instruction

The second Merriam-Webster definition of learning refers to knowledge acquisition that is the result of instruction or study. This definition largely relates to instructional design. The influential instructional design textbook by Gagné et al. (2005), Principles of Instructional Design, defined instruction as "a set of events embedded in purposeful activities that facilitate learning", including "selecting materials, gauging student readiness to learn, managing class time, monitoring instructional activities" (1). Teaching is seen as one aspect of the broader category of instruction, where instruction is the "whole range of activities the teacher uses to engage the students". These support the act of teaching but are not necessarily a form of teaching itself. (2)

Gagné et al.'s approach to instructional design is based on Atkinson and Shiffrin's stage theory model (or model of memory). Developed in 1968, Atkinson and Shiffrin's stage theory model views learning as "information processing that consists of a number of stages between perception and memory". Although Gagné et al. acknowledged the existence of other models of memory—such as the parallel-distributed processing (or connectionist) model—they adopted the stage theory model because "we don't really know exactly how the brain works" and the stage theory model does offer "a number of insights about how to design instruction that facilitates learning". Thus, many of the instructional design principles described in Principles of Instructional Design are built on the stage theory model framework. (7)

This can be largely attributed to instructional design's military origins—it is said to have originated during World War II and was used in the production of military training materials (Brown 2010). These forms of early instructional design typically adopted a behaviourist approach. According to the Encyclopædia Britannica online, classical behaviourism is "based on the belief that every response is elicited by a specific stimulus". Gagné et al. referred to learning as a process that affects behaviour, but also made references to the internal changes that produce the visible behaviour. They defined learning as "a natural process that leads to changes in what we know, what we can do, and how we behave" (2005, 1) and "a process that leads to a change in a learner's disposition and capabilities that can be reflected in behavior [sic]" (3). Thus, their approach reflects the tendency of instructional design as a discipline to rely on systems-based approaches to learning. This has led instructional design to alternatively being dubbed as "the systems approach, instructional systems design (ISD), instructional development" and used to describe "sets of systematic instructional design procedures (or models)" (Reiser 2001, 58).

Learning from experience

The last Merriam-Webster definition describes learning as the result of experience. Similarly, Pine and Boy (1977, cited in Boy and Pine 1999, 221) declared, "Learning is a consequence of experience." This notion of learning from experience goes beyond formal education. After all, humans have been learning from experience even before the creation of schools and other educational institutions. It can be traced as far back as 350BCE, when Aristotle wrote in *Nicomachean Ethics*, "for the things we have to learn before we can do them, we learn by doing them" (Aristotle 350BCE). It is also supported by anthropological research on hunter-gatherer children which found that learning occurred even where schools did not exist. This includes the following observations Gray (2008a) made about learning in hunter-gatherer societies:

- » Learning was necessary "to become successful adults".
- » There was a large volume of knowledge that had to be learnt.
- » Learning occurred in the absence of formal teaching.
- » Learning did not occur during set times—it resulted from the time children spent on play and exploration, which was typically "most if not all of the day, every day".

» Children learnt by observing "adults' activities and incorporate those activities into their play".

Agriculture and industry subsequently led to a shift away from the hunter-gatherer method of play-based and exploration-based learning (Gray 2008b). This was because hunter-gatherer societies were dependent on skills and knowledge, but agriculture-based societies were dependent on labour. The labour-intensive nature of agriculture—and later, industry—required "long hours of relatively unskilled, repetitive labor [sic]", and children were seen as a prime source of such labour. Physical force or corporal punishment were used to ensure compliance from children in farming and factory work. These same methods were later also sometimes used in early formal education, alongside repetition and memorisation. As a result, play and learning were seen as diametrically opposed: "play was not considered to be a vehicle of learning … play was the enemy of learning". (Gray 2008b) Today, this is not the case. This is in large part because of the rise in the popularity of play-based learning and constructivism (or active learning), both of which see experiences as having an important role in learning.

Changes in learning and education

To some extent, it can be said that the changes in learning and education have contributed to the blurring of the divide between the three Merriam-Webster definitions. Learning is no longer viewed as task-based, in which a single task or activity leads to the acquisition of a single skill that produces a change in behaviour. Rather, it is now beginning to be thought of in a greater context, as an experience from a range of different knowledge and skills can be learned simultaneously in the context of real world environments, that can then be applied to real life. It is important to recognise that these changes in learning and education have happened progressively over time. To better understand these changes, the approaches to learning that have led to the shift from task-based learning (or learning from instruction) to experience-based learning are examined here. These include play-based learning, active learning and constructivism, and Kolb's experiential learning theory.

Play-based learning

Moore et al. (2014) explored the evolution of ideas in relation to play-based learning, and their overview of this is comprehensive and concise. Hence, their work is used as the main reference in this section. They noted that the concept of play-based learning began to gain popularity from the eighteenth century onwards and was largely influenced by the work of Jean Jacques

Rousseau, Fredrich Froebel, and the pragmatist John Dewey (Moore et al. 2014). Rousseau is known for his "idealistic" and "romantic" views of children and childhood, where children are seen as innocent and in need of protection (12). His work is said to have been the foundation for child-centred approaches to education. Froebel is recognised as "the creator of the first 'kindergarten' or 'children's garden'" (13). He proposed that, through play, children would "learn to live in harmony with others and nature" (Platz and Arellano 2011, quoted in Moore et al. 2014, 13). He strongly believed in the importance of self-direction and firsthand experience in early childhood education, and that play should be located within the context of a child's actual living environment in order to be "educative, serious and meaningful" (Froebel 1833, quoted in Liebschner 1993, 56). Dewey also believed that learning should be child-centred, self-directed, and occur in "social and meaningful contexts" (Moore et al. 2014, 14). Additionally, he emphasised the importance of providing "many different experiences" from which children could construct their own learning (14).

Moore et al. also highlighted the significance of Jean Piaget's work in early childhood education[64]. Piaget was a psychologist who proposed that the cognitive development of young children occurred in stages, in line with their biological development, as they progressed toward maturity (15). His theory resonated with the existing ideas about learning through play that were influenced by Froebel and Rousseau[65], and eventually became "firmly entrenched in understandings about appropriate early childhood education" (16). It also led to debate regarding the efficacy of play-based learning (Gibbons 2007; Hedges 2010; Yelland 2011, all cited in Moore et al. 2014, 16) and laid the foundation for postdevelopmental perspectives[66] on early childhood education.

One of the most significant postdevelopmental perspectives was the work of psychologist Lev Vygotsky[67]. Vygotsky saw learning as a sociocultural phenomenon; we learn from social interactions that occur within a culture. His views produced a shift in play-based learning, moving "from a focus on symbolic exploration to an intentional focus on learning" (18). This

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[64] Piaget is discussed in more detail in "Active learning and constructivism" on page 114.

[65] It has been proposed that his work may have been applied to early childhood education because of this (Krogh and Slentz 2010, cited in Moore et al. 2014, 15).

[66] Postdevelopmental perspectives is a collective term used to refer to the different "alternative theoretical perspectives that question modernist assumptions of truth, universality, and certainty" (Blaise 2009, 452)

[67] Vygotsky is discussed in more detail in "Active learning and constructivism" on page 114.

led to the emergence of pedagogical play[68], in which play is more purposeful (and thus less open-ended and exploratory). It also resulted in educators adopting a more active role, since it was thought that "content knowledge is constructed by children in concert with educators who already hold some degree of knowledge themselves". (Moore et al. 2014, 19) In this sense, play-based learning can also be seen as a form of active learning.

Active learning and constructivism

The term active learning is so widely used today that its definition has become rather general. Prince (2004, 223) offered a reasonably concise definition:

> Active learning is generally defined as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing. While this definition could include traditional activities such as homework, in practice active learning refers to activities that are introduced into the classroom. The core elements of active learning are student activity and engagement in the learning process. Active learning is often contrasted to the traditional lecture where students passively receive information from the instructor.

The concept of active learning is underpinned by the learning theory known as constructivism. Constructivism has received increasing attention over the last twenty years due to the rise in popularity of the term 'active learning' in education (Koohang et al. 2009). Constructivism asserts that in any learning situation, the learner "constructs meaning and understanding based on prior experiences, knowledge, and a host of other personal 'filters'" (Hannum and McCombs 2008, 16). In constructivism (or constructivist learning theory), active learning is seen as a classroom-based learning process that requires independent, self-directed activity, which promotes meaningful knowledge construction and long-term retention (Narli 2011). Students are responsible for their own learning, while teachers act as facilitators, creating opportunities for students to engage in self-directed learning (McMahon 1997, in Napierala 2011). This means that, given the same learning situation, what each individual learns is unique, and the learning experience of each learner is different.

There are two distinct constructivist learning models: individual constructivism and social constructivism (Almala 2006). Individual constructivism was proposed by Jean Piaget, while

[68] Pedagogical play refers to play that is "used in early childhood education to support learning" (Moore et al. 2014, 19).

social constructivism was proposed by Lev Vygotsky[69]. The difference between the two models is primarily the way in which knowledge is acquired. In individual constructivism, knowledge acquisition is thought to occur via the individual learner's personal experience. In social constructivism, the knowledge the individual learner acquires is thought to be the result of personal experience as well as social interaction (e.g. dialogue, collaboration, etc.). Like Vygotsky, Gagné et al. (2005) acknowledged the significance of external influences on an individual's learning, including the learning environment, contexts, and social interaction that form the individual's learning experience:

> Learning is affected by sociocultural expectations, values, and declared or public knowledge. The learner is not an isolated being, and the context in which learning takes place interacts with what is being learned, and the processes of learning. (4)

However, there are others (e.g. Hannum and McCombs 2008) who propose that Piaget's view was equally important, emphasising that even though social interaction can influence learning, "what any one person learns and remembers, the information learned and its associated emotional context is uniquely a learner's own" (Hannum and McCombs 2008, 16).

Constructivism and instructional design

It has been suggested that the theory of constructivism can be used improve instructional design. Brooks and Brooks (2001, quoted in Napierala 2011, 12-13) noted that constructivist classrooms give students "the exhilarating power to follow trails of interest, to make connections". Swan (2005, 18) stated that constructivism "locates meaning and meaning making squarely in the mind of individuals, and not in instruction." Gagné et al.'s (2005) traditional systems view of instructional design, which is focused on knowledge acquisition through a series of activities performed in a systematic progression, relates to individual constructivism to some extent, since the design of the activities can be based on individual learner's personal experiences that have already taken place.

However, the systems-based approach in instructional design is less compatible with social constructivism. With social constructivism, knowledge acquisition is seen as being impacted by both prior knowledge and social interaction. The presence of social interaction means that the learning situation is in a constant state of flux which, according to Kanuka, is a more accurate reflection of how we learn:

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[69] Piaget and Vygotsky were two of the early pioneers of constructivist theory.

> According to radical social constructivists, there is nothing systematic about how we learn or construct knowledge (Kanuka & Anderson, 1999). Rather, knowledge is constructed socially using language (Vygotsky, 1962). As no two individuals have exactly the same social experiences, there exist multiple realities of how the world works." (Kanuka 2006, 4-5)

If we view learning from a social constructivist perspective, this means a systems-based approach is unsuitable, since the type and order of the learning activities cannot be predetermined. At the same time, it highlights the main criticism of the systems view of instructional design—that it does not accurately reflect the actual learning process, which is a lot more messy and spontaneous (and a lot less orderly and sequential).

It is possible to apply social constructivism to instructional design, however instructional designers and educators must take into consideration the following: (1) "there are multiple dimensions of what the truth must be and learning is based on prior knowledge"; (2) "learners will require a variety of different experiences to advance to different kinds and levels of understanding"; and (3) as educators, they "need to spend time understanding their learner's current perspectives and, based on this information, incorporate learning activities that have real world relevance for each learner" (Kanuka 2006, 5). It would also be useful to consider the following five tenets of constructivism identified by Almala (2006, 35): "a complex and relevant learning environment", "social negotiation", "multiple perspective and multiple modes of learning", "ownership in learning", and "self-awareness and knowledge construction".

Another way to apply social constructivism in instructional design is to focus on designing learning environments that are learner-centred, knowledge-centred, and community-centred, not just designing learning materials (Swan 2005, 18). This is a view shared by some instructional designers, such as Brown, who stated, "instructional designers design not only materials but also experiences" (2010, 27). The idea of constructing experiences is not new. Pullman and Gross (2004) proposed the creation of holistic experiences for the service industry. Zappen, Harrison and Watson (2008) did the same for information design. In e-learning, where electronic educational technology is used in teaching and learning, Kanuka (2006, 9) proposed integrating pedagogical content knowledge with instructional design. Miller, Veletsianos and Hooper (2006, 17) proposed that instructional designers should focus on the creation of an "aesthetic instructional experience" in which form and function are complementary—aesthetics "should exist at the core" of instructional design instead of being applied at the end of the process.

Creating an aesthetic instructional experience is essentially what learning experience design is about, since both view the learning experience as a whole and not just the sum of its parts. Malamed highlighted that contemporary instructional design's focus on user-centred design is very different traditional instructional design's focus on designing learning materials, so much so that she proposed 'instructional design' be renamed 'learning experience design'. She argued that learning experience design more accurately reflects "the unique nature of how we design", since the name "Learning Experience Design emphasizes the learning rather than the instruction" and "Learning Experience Designers ... design, enable or facilitate experiences rather than Courses". (Malamed 2015)

Learning experience design can be said to align with the view that form and function are complementary design goals. Zappen, Harrison and Watson (2008, 20) described this view (in the context of experience design) as a "more balanced" approach to the form versus function dichotomy. The proponents of function (Nielsen 2012) place the emphasis on content, usability and efficiency, much like the traditional systems view in instructional design. Proponents of form (Anderson 2009; Norman 1988) are more concerned with aesthetics—here this can be described as the conflation of experience design and instructional design, where learning is influenced by the aesthetics of the experience and the resulting emotions (e.g. Dong 2007). So unlike systems-based traditional instructional design, learning experience design takes a more holistic approach which sees aesthetics used in conjunction with a scientific, model-based methodology to produce a learning experience, rather than a set of learning materials.

Learning experience designers must thus know what constitutes a good experience and how to create it using "the desired media without the technology dictating the form of the experience" (Shedroff 2001, quoted in Zappen, Harrison and Watson 2008, 19). The emphasis is on "the total user experience, utilizing [sic] the full resources of the available media" (Zappen, Harrison and Watson 2008, 19), where interactivity is one such resource (Shedroff 2001, quoted in Zappen, Harrison and Watson 2008, 19). This means taking into consideration the content, structure, and delivery method of what needs to be learnt, as well as the personal traits of the users (e.g. learning ability, previous knowledge, personal goals, etc.), and being able to translate this into a relevant learning experience.

Experiential Learning Theory

Kolb's experiential learning theory (ELT) is one of the more significant and recent attempts to incorporate learning through experience in formal education. Most educational studies that relate to Kolb's experiential learning theory focused on higher education, while "K-12 education accounts for a relatively small number" (Kolb, Boyatzis, and Mainemelis 2011, 235). His theory is visually represented in the Experiential Learning Cycle (Figure 3). Kolb developed this theory in 1984, drawing on the works of John Dewey in philosophical pragmatism, Kurt Lewin in social psychology, and Jean Piaget in cognitive-developmental genetic epistemology (Kolb 1984, cited in Kolb, Boyatzis, and Mainemelis 2011, 227).

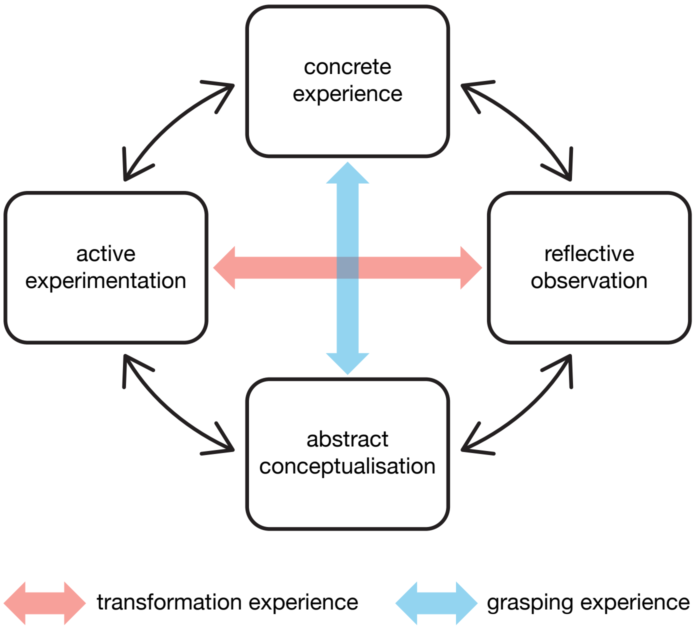

Figure 3: Kolb's Experiential Learning Cycle (adapted from Figure 1 in Kolb and Kolb 2009, 299)

Kolb saw learning as a process that creates knowledge through the combination of what he called grasping experience and transforming experience, each of which consists of "two dialectically related modes" (Kolb 1984, cited in Kolb, Boyatzis, and Mainemelis 2011). Grasping experience consists of concrete experience and abstract conceptualisation; transforming experience consists of reflective observation and active experimentation (Kolb, Boyatzis, and Mainemelis 2011, 298). Kolb thought learners would construct knowledge through a recursive process in which they would cycle through all four modes, actively choosing which mode(s) to use, in response to what they are learning and to the learning situation (Kolb, Boyatzis, and Mainemelis 2011, 228).

Learning and literacy

Learning is distinct from literacy. Learning is a broad term that generally refers to a process of knowledge acquisition that produces behavioural changes. Literacy, on the other hand, is much more specific—it is typically used to refer to the ability to acquire and share knowledge through reading and writing respectively. This has changed in the past few decades, largely due to technological and cultural changes. These changes have, in turn, resulted in the evolution of the meaning and use of the term 'literacy'.

Definitions and types of literacy

The word 'literacy' has been used in so many contexts and exists in so many variations that pinpointing a single definition is difficult, if not impossible. Traditionally, literacy is considered distinct from orality (Ong 1982, cited in Erstad 2010), and refers to the ability to read and write. The conceptual understanding of literacy changed in the 1970s and 1980s as new literacy studies were conducted (Erstad 2010). Literacy was first considered to be an autonomous and transferable set of skills that could be used "in different contexts and for different purposes to complete a set of tasks". Several researchers criticised this concept of literacy for being too limited, and expanded it to include sociocultural influences, such as "the different ways people use language and the different systems of representation in social practices". (35)

Macedo and Steinberg's (2007) offered a fuller and more complete definition. They defined literacy as "gaining competencies involved in effectively learning and using socially constructed forms of communication and representation", noting that it specifically involves "gaining the skills and knowledge to read, interpret, produce texts and artifacts, and to gain the intellectual tools and capacities to fully participate in one's culture and society". As we saw earlier, the history of education largely owes its existence to the resulting need and desire for literacy once printed books became commonplace. This was also emphasised by Macedo and Steinberg, who wrote "education and literacy are intimately connected". (4–5)

Today, the word 'literacy' is often seen in the company of other words. Walsh (2010) observed that the evolution of the terminology surrounding literacy reflects the changes that have occurred in media, technology and communication (213). With the number of literacies being used today, there is bound to be some confusion, so it is necessary to briefly examine each of the following literacies: visual literacy, media literacy, digital literacy, computer literacy, technology literacy, information literacy, web literacy, multimodal literacy, and multiliteracy.

Visual literacy

Of the various literacies listed above, visual literacy has been around the longest. Despite this, there is still a lack of agreement as to its meaning. Avgerinou and Ericson (1997) acknowledged that "defining [visual literacy] is far from an easy task" (283). They discussed several definitions of visual literacy that have been proposed by people from various disciplines, including those by Debes, Ausburn and Ausburn, Hortin, and Curtiss. The origin of the term was attributed to John Debes, who referred to visual literacy as:

> a group of vision-competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences. The development of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person to discriminate and interpret the visible actions, objects, symbols, natural or man-made, that he encounters in his environment. Through the creative use of these competencies, he is able to communicate with others. Through the appreciative use of these competencies, he is able to comprehend and enjoy the masterworks of visual communication. (Debes 1969, quoted in Avgerinou and Ericson 1997, 281)

Unsurprisingly, some found issue with the ambiguity of Debes' definition. Avgerinou and Ericson themselves described Debes' definition as "too expansive and somehow misleading, since it emphasises the way (senses) the stimuli are received without mentioning anything about their form (symbolic)". At the same time, they acknowledged that Debes intended his definition to be "tentative"—he described visual literacy as "a multi-faceted subject with many unexplored parameters", in an attempt to highlight how little he or anyone knew about visual literacy at the time. They also referred to criticisms by Bieman and Levie. Bieman's complaint was that "the definition does tell us what a visually literate person can do, but not what visual literacy is". Levie criticised Debes' definition for defining visual stimuli "in terms of a sensory modality rather than a symbolic modality". Additionally, Avgerinou and Ericson observed that it did not differentiate between verbal and visual literacy—in particular, between visual stimuli that are "non-arbitrary, iconic and representational" and those that are "arbitrary, digital and non-representational". (Avgerinou and Ericson 1997, 281)

Avgerinou and Ericson also reviewed other definitions that were generated in response to Debes'. Ausburn and Ausburn defined visual literacy "as a group of skills which enable an individual to understand and use visuals for intentionally communicating with others" (1978, quoted in Avgerinou and Ericson 1997, 281). Hortin built on Ausburn and Ausburn's definition—"Visual literacy is the ability to understand (read) and use (write) images and to think and learn in terms of images, ie, to think visually" (1983, quoted in Avgerinou and Ericson 1997, 281). Curtiss, in turn, expanded on Hortin's definition:

> Visual literacy is the ability to understand the communication of a visual statement in any medium and the ability to express oneself with at least one visual discipline. It entails the ability to: understand the subject matter and meaning within the context of culture that produced the work, analyse the syntax—compositional and stylistic principles of the work, evaluate the disciplinary and aesthetic merits of the work, and grasp intuitively the Gestalt, the interactive and synergistic quality of the work. (Curtiss 1987, quoted in Avgerinou and Ericson 1997, 282)

Avgerinou and Ericson called Hortin's definition "the most complete in terms of both form and content", but for one thing—it failed to "address the issues of design, creativity, and aesthetics". Even though Curtiss' version appeared to address those issues, they found it was too lengthy and descriptive to function effectively as a definition. (282) Overall, Avgerinou and Ericson (1997) found that visual literacy has been so difficult to define because of the combination of two factors: firstly, the relevance of visual literacy across so many disciplines, and secondly, the tendency of people from different disciplines to emphasise different aspects of visual literacy based on what is applicable to their own discipline. Furthermore, as a research topic, it has generated numerous instances of contradictory findings.

The difficulty in defining visual literacy can also be tied to two other contentious issues: how to determine if someone is visually literate and how to determine proficiency in visual literacy. Carpenter II and Cifuentes (2011, 33) suggested that to be visually literate means having the necessary skills to interpret and create visual material in a sophisticated manner. In other words, the ability to consume visual material is not visual literacy (Mirzoeff 1999, cited in

Carpenter II and Cifuentes 2011, 33); neither does the prolific consumption of visual material necessarily result in higher levels of visual literacy. Brumberger (2011) observed that students who fit the criteria of being a digital native did not always "demonstrate a high level of visual literacy". At the same time, she questioned whether it was necessary to be able to create and interpret visual material in order to be considered visually literate: "although we may define visual literacy as both productive and interpretative, a less comprehensive set of criteria may be more realistic—and still appropriate—for many students". Thus, "the question needs to be not just how proficient students are, but how proficient they need to be". (Brumberger 2011)

Media literacy

In the textbook *Media Literacy*, Potter (2008, 19) described media literacy as "a set of perspectives that we actively use to expose ourselves to the media to interpret the meaning of the messages we encounter". Therefore, for a person to be media literate, they must be able to make deliberate choices in their consumption of media. This includes choosing the perspective(s) to adopt when deriving meaning from media content, which requires an awareness of different perspectives as well as the ability to consciously adopt one or more of these perspectives. Erstad (2010, 34) defined media literacy as "[the] ability to access, understand and create communications in a variety of contexts". Unlike Potter, Erstad included an additional dimension in his definition: authorship. This is a broader definition of literacy, in which literacy is about knowing how to create meaning, not just how to access and interpret it. Erstad also emphasised that "the social and cultural influences of different media in our society" should be a focal point in the teaching of media literacy (Erstad 2010, 35).

In other words, media literacy is not just about having the ability to acquire information using media; it is more about the ability to find and acquire contextually relevant information. This requires the following:

» the ability to choose and use appropriate media from which to acquire information;
» the ability to choose and use the necessary tools to acquire information;
» the ability to determine what information is relevant to the context;
» the ability to interpret the information that has been acquired;
» the ability to create media content for the desired media using the information that has been acquired; and
» the ability to understand how the acquired information and the generated content affects and is affected by existing media (and media content).

To be able to perform all of the above arguably requires certain levels of both functional and critical media literacy. In the context of media literacy, Buckingham et al. (2005, 3) defined functional literacy as “the skills and competencies needed to gain access to media content, using the available technologies and associated software”. Functional literacy enables learners to “locate what they [are] looking for” (10). Critical literacy, on the other hand, is needed “to interpret, critique and manage that information” (10). Facer et al. found that although children over the age of nine were functionally literate enough to find the information they needed, they were not critically literate enough to move “beyond information to knowledge and understanding” (Facer et al. 2003, cited in Buckingham et al. 2005, 10). The reverse can also be true—there are those who have high levels of critical literacy but lack the functional literacy to use newer forms of digital technology (e.g. tablets, smartphones) to access the information they need.

Digital literacy, computer literacy and technology literacy

Digital literacy, computer literacy, and technology literacy generally refer to competency and skill in the use of digital media and technology, computers, and technology respectively. The 1999 report *Being Fluent with Information Technology* described computer literacy as “implying competency with a few of today’s computer applications, such as word processing and email” and that it “has acquired a skills connotation” (Erstad 2010, 34). The report was generated by the National Research Council Committee on Information Technology Literacy (NRC) and commissioned by the National Science Foundation in the United States. Erstad also noted, “Other concepts like ICT literacy, digital competence, and digital literacy have later been used to indicate the same advanced use of technology as that which is denoted by fluency in the aforementioned quote, at the same time taking technological developments into consideration.” (Erstad 2010, 35)

Information literacy and web literacy

Information literacy “indicates both the ability to recognize when information is needed and how to locate, evaluate, and use effectively the needed information” and its importance has grown in line with “the increasing importance of the World Wide Web as a source of information” (Erstad 2010, 37). The popularity of the World Wide Web as an information source also led to introduction of the term ‘web literacy’. The usage of the term ‘web literacy’ suggests that it is distinct from information literacy, in that it is more about the skills required to interpret the different types of information gleaned specifically from the Web, as opposed to information literacy, which is more about how to find the necessary information for use in a given situation. Sorapure, Inglesby and Yatchisin (1998, 410) stated that web literacy "involves an ability to recognize [sic] and assess a wide range of rhetorical situations and an attentiveness to the information conveyed in a source's nontextual features" and that those who are web literate should be able to employ "strategies necessary for making sense of diverse kinds of texts presented in hypertextual and multimedia formats".

It is also important to point out that web literacy is also distinct from technology literacy (and by association digital literacy and computer literacy—see above). Technology literacy is concerned with functional literacy (i.e. the skills required to use technology), while web literacy is more about critical literacy (i.e. the skills required to find and evaluate information).

Multimodal literacy and multiliteracy

The availability of information in an increasing variety of media (e.g. books, computers, etc.) and modes (e.g. oral, visual, etc.) has led to the creation of additional terms to describe the literacy needed to juggle these. Multimodal literacy and multiliteracy are two such terms. Although they appear similar, multimodal literacy and multiliteracy are distinct from each other. Multimodal literacy is about being literate in different modes of communication (e.g. reading, writing, listening, etc.):

> Multimodal literacy refers to meaning-making that occurs through the reading, viewing, understanding, responding to and producing and interacting with multimedia and digital texts. It may include oral and gestural modes of talking, listening and dramatising as well as writing, designing and producing such texts. The processing of modes, such as image, words, sound and movement within texts can occur simultaneously and is often cohesive and synchronous. Sometimes specific modes may dominate. For example, when processing screen-based texts the visual mode may dominate whereas the mode of sound may be dominant in podcasts. (Walsh 2010, 213)

In contrast, multiliteracy refers to being literate in multiple literacies (e.g. technology literacy, media literacy, visual literacy, etc.):

> To the domains of reading, writing, and traditional print literacies, one could argue that in an era of technological revolution educators must develop robust forms of media literacy, computer literacy, and multimedia literacies, thus cultivating 'multiple literacies' in the restructuring of education. Computer and multimedia technologies demand novel skills and competencies, and if education is to be relevant to the

> problems and challenges of contemporary life, engaged teachers must expand the concept of literacy and develop new curricula and pedagogies. (Macedo and Steinberg 2007, 5)

Clearly, the changes in media and technology are largely responsible for the emergence of new literacies such as digital literacy, web literacy, media literacy, and multiliteracy. At the same time, these changes can also be held responsible for shifting society's perceptions of literacy and visual literacy by facilitating the use of visuals in communication, prompting significant cultural change in terms of the way we use visuals and also by challenging the dominant view that words are superior to images. These changing perceptions of literacy and visual literacy are examined in the following section.

Literacy versus visual literacy

Just over a decade after Stafford wrote about "the current drive to visualize everything" (1996, 73), Dallow declared, "It is said that we now live in an image-centred visual culture" (2008, 92). However, although the dominance of the image seems to be a recent phenomenon, it actually is not. Visuals have always been important—even when the written word was considered superior to the image, as well as before that. The English language provides ample evidence of this; it contains "a range of idiomatic ways of referring to visual mental imagery: 'visualizing,' 'seeing in the mind's eye,' 'having a picture in one's head,' 'picturing,' 'having/seeing a mental image/picture,' and so on" (Thomas 2014)[70].

And while Martin Jay (1988, 3) argued that the dominance of the visual began in the modern era[71], looking back further we can see that visuals have provoked intense study and fascination well before that. Philosophy, science and art are all built on the notion of visuals and images. Michael Tye (1991) listed a string of influential philosophers for whom the visual (or the image) was of paramount importance: Aristotle, Descartes, Hobbes, Locke, Berkeley, and Hume[72]. In *The Stanford Encyclopedia of Philosophy*, Thomas (2014) stated, "Images … are undoubtedly central to [Hobbes'] cognitive theory". For the majority of us who have functioning vision, visuals

[70] By contrast, there are comparatively "fewer ways to talk about imagery in other sensory modes" in English (Thomas 2014).

[71] "The modern era, it is often alleged, has been dominated by the sense of sight in a way that set it apart from its premodern predecessors and possibly its postmodern successor. Beginning with the Renaissance and the scientific revolution, modernity has been normally considered resolutely ocularcentric. The invention of printing, according to the familiar argument of McLuhan and Ong, reinforced the privileging of the visual abetted by such inventions as the telescope and the microscope." (Jay 1988, 3)

[72] Tye provided an overview of each of their views, these are discussed in detail on page 142.

provide us with information about—and facilitate our interaction with—our environment and everything within it. They also function as representations of the invisible (e.g. X-rays), and the abstract (e.g. Modernism), as well as "the stuff of memory, the way in which the brain internally displays thoughts to itself" (Stafford 1996, 73).

Visuals also contributed to the development of written communication. Early forms of written language, such as hieroglyphics, as well as languages used today (e.g. mandarin chinese) were based on visual representations of real world objects. These early representations paled in comparion to real life. However, when artists discovered the use of perspective and other painting techniques that increased the realism in man-made imagery, accurate depictions of the real world became possible. This resulted in a growing suspicion of images: "For iconoclastic philosophers and enlightened reformers, image manipulation was the hallmark of the charlatan equipped with the latest technology projecting deluding special effects" (Stafford 1996, 46).

Such suspicion was not unfounded. Sherwin noted that the ability of visuals to elicit emotion made them more effective at persuasion than words alone (2008, 184). The persuasivness of visuals is a key reason why visual media is so popular:

> Movies, television and other image-based entertainments have overwhelmed text-based media in popularity largely because they seem to simulate reality more thoroughly, engulfing the spectator (or, in the case of interactive computer and video games and immersive virtual environments, the participant) in vivid, life-like sensations. (Sherwin 2008, 184)

It is also the reason that visuals were—and are—viewed with contempt and suspicion.[73] This negative perception of visuals was exacerbated by the belief that language is the product of higher level cognitive thought (Stafford 1996, 5), a belief which necessarily rendered visual media as being superficial and shallow, and simultaneously portrayed text-based media as intellectually superior. Hughes (1995), for example, saw reading as "a collaborative act" that requires "effort" and is "far better for the imagination". At the same time, he derided television viewing for being "passive".

This ranking of language above visual has been the status quo for much of the history of education, cemented in place by several key events: the dominance of science over art, the invention of the printing press, and the introduction of formal education and schooling. The

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[73] See also Stafford (1996).

combined outcome of these events was a heavy emphasis on traditional literacy (i.e. reading and writing) in formal education and the neglect of visual literacy, since it was believed that one did not need instruction in order to be able to interpret visuals—"looking at a photograph, talking on the phone, listening to a phonograph recording, watching a movie, listening to the radio, watching TV require no learning on the basic perceptual or performance level at all" (Levinson 2001, 31). The ease with which we derive meaning from visuals has also led to declarations that the Internet is making us stupid (Bauerlein 2009; Carr 2008), yet it is also largely the reason for the increasing popularity of visual content on the Internet in recent years (e.g. memes, GIFs).

Indeed, the Internet and a host of related technologies can be collectively held responsible for the ascendance of visuals and visual literacy. The first of these changes came with the advent of Web 2.0[74] technologies. These technologies are typically dynamic and allow for socially-driven information exchanges—they are characterised by a culture of collaboration, participation, sharing and creativity (Harrison and Barthel 2009). Examples of Web 2.0 technologies include social media (e.g. Facebook, Twitter), blogs, wikis (e.g. Wikipedia), and media sharing websites (e.g. YouTube) (Pifarré and Li 2012). The arrival of personal mobile devices such as tablets and smartphones resulted in more widespread use of these technologies. Furthermore, because these devices gave users the ability to instantaneously create, receive and transmit visual information all the time, at any time, this saw them gain a huge rise in ownership and usage (Rosen 2010). This rapid evolution of hardware and software technology, together with ever-increasing Internet speeds, propelled a surge in the exchange of visual information.

One could say that our preference for communicating using visuals exists because computer technology and images can now be used to create interactions that closely resemble real-life interactions. On the other hand, it may be because we have always wanted to communicate using images but simply lacked the necessary technology[75]. Or perhaps it might be that images are simply more effective in communicating abstract notions such as emotions. This can be seen in the use of what McWhorter called 'graphic titter'. Graphic titter refers to the word combinations used to evoke images of a scene or action. It "warms texting up into a graphic kind of spoken conversation" and thus allows for the creation of nuances that written text lacks in comparison to real-life interaction and visual representations (McWhorter 2014). Looking

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[74] See page 87 for definition of Web 2.0.

[75] This is also discussed in "Interactivity and communication" on page 76 and "Interactivity and the search for the perfect simulation" on page 98.

at the use of 'lol'[76], McWhorter also noted that it is no longer just used for its literal meaning, but it also "now serves the same function as the quiet chuckles and giggles that decorate most casual conversations". In other words, graphic titter allows subtext (e.g. body language, setting, context, etc.) to be communicated simultaneously.

This need for including subtext can also be used to explain why emojis are so popular (and might even replace graphic titter). Sternbergh (2014) used psychologist Albert Mehrabian's study to justify the importance of subtext in texting. Mehrabian's study showed that "only 7 percent of communication is verbal (what we say), while 38 percent is vocal (how we say it) and 55 percent is nonverbal (what we do and how we look while we're saying it)", so Sternbergh concluded, "when we're texting, 93 percent of our communicative tools are negated". However, since the introduction of emojis has shifted texting on mobile devices from being text-only to being a combination of text and images, this has given texting nuances that, in some ways, replicate the way we communicate in real life. As Sternbergh explained,

> This elasticity of meaning is a large part of the appeal, and perhaps, the genius of emoji. They have proved to be well suited to the kind of emotional heavy lifting for which written language is often clumsy or awkward or problematic, especially when it's relayed on tiny screen, tapped out in real time, using our thumbs. (Sternbergh 2014)

Still, even though the use of visuals is growing in popularity, language continues to play an important role since reading is "essential to even the most iconic of computer systems" (Levinson 2001, 31). This is not to say that the dominance of language as a communication tool will not continue to be challenged. The introduction of mobile apps in the last few years has already seen the media environment become significantly more visual, as the trend interpretation agency TrendsActive noted:

> Even day-to-day communication is becoming more visual. It started with the use of smileys and emoticons and is now progressing towards completely visual communication. This explains why teens are turning to Tumblr online, and why they are turning to Snapchat on their mobile phones. (TrendsActive 2015)

Indeed, several of the most successful mobile apps—including Tumblr, Snapchat, Pinterest, and Instagram—rely heavily on visual content and require little to no reading. While this does not mean that text-based mobile apps are destined for failure, they do need to take into account the ways in which our reading behaviour has changed over time.

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76 The acronym 'lol' stands for 'laugh out loud'.

Some have suggested that online reading is generally less focused and more superficial (Liu 2005 ; Liu and Huang 2016; Manjoo 2013; Rosenwald 2014; Rosenwald 2015). When examining changes in reading behaviour in the USA over a 10-year period, Liu (2005) found that sustained attention declined with online reading and people were less likely to read in-depth. More recently, Liu and Huang (2016) surveyed 205 undergraduate students in China and found that reading behaviour differed on smartphones versus desktop or laptop computers. In comparison with reading on laptop or desktop computers, reading on smartphones tended to involve more browsing and scanning, more selective reading, and less in-depth and concentrated reading. They also found that digital natives preferred reading on paper, particularly when the content is unfamiliar or difficult, or when learning and retention is the goal. Data scientist Josh Schwartz from the traffic analysis firm Chartbeat[77] found that although most people will view all the video and photo content in online articles, they are unlikely to read to the end of a long article (Manjoo 2013).

Writing for *The Washington Post*, Rosenwald (2015) observed, "Textbook makers, bookstore owners and college student surveys all say millennials still strongly prefer print for pleasure and learning, a bias that surprises reading experts given the same group's proclivity to consume most other content digitally." He also mentioned Naomi Baron and her book *Words Onscreen: The Fate of Reading in a Digital World*, noting that Baron also found that digital native readers were more prone to scanning and skimming when reading online, while tending toward slower, more thoughtful in-depth reading when reading in print. In another article, Rosenwald (2014) interviewed cognitive neuroscientist Maryanne Wolf, author of *Proust and the Squid: The Story and Science of the Reading Brain*, and described how she and others found that our ability to read in print is negatively impacted by the increasing amount of time we spend online consuming digital content; this is because of neuroplasticity. In layman's terms, Wolf explained neuroplasticity as meaning the brain "is plastic its whole life span" and "is constantly adapting". (Rosenwald 2014)

Thus, if we want our brains to be bi-literate in both online reading and reading in print, we need to maintain a balance between the two. In the same respect, it is naïve to emphasise literacy over visual literacy for this reason—both play important roles in communication and in our understanding of the world around us.

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[77] The following year, the CEO of Chartbeat, Tony Haile, wrote in *Time* magazine that "one in every three visitors spend less than 15 seconds reading articles they land on" but noted that high quality content could sustain users' attention for a longer periods (Haile 2014).

Learning and technology

In the previous section, Web 2.0 technologies were described as having the following characteristics: collaboration, participation, sharing and creativity (Harrison and Barthel 2009). However, although these characteristics allow Web 2.0 technologies to offer obvious benefits in contemporary constructivist classrooms, they have also made the work of educators and instructional designers more complicated. This is because there is no one-size-fits-all solution that will suit all learners. Two main issues make the decisions surrounding the creation of learning experiences complex and difficult, and fraught with uncertainty: the fragmentation of learning and the conflicting views on technology. The fragmentation of learning refers to the new learning types that have emerged as a result of new technologies. The new learning types discussed here are blended learning, e-learning, and game-based learning. The conflicting views of technology explored here centre on three key areas: the 'digital native' phenomenon, digital technology use in education, and the effects of digital media use and exposure.

The fragmentation of learning

The introduction of all the various technologies over the past few decades has resulted in the fragmentation of learning into various different types. So, in addition to what is now called traditional learning there are now a host of new learning types, with new terms to describe each. This includes blended learning, e-learning, and game-based learning (or the gamification of learning). Blended learning attempts to combine technology, text, and visuals, through the selection of delivery methods and activities. The term 'blended learning' is used to describe the combined use of different media and technologies. According to Gagné et al. (2005, 224):

> The term blended learning refers to a training product or program that combines several different delivery methods, such as collaboration software, online courses,

> electronic performance support systems, and knowledge management practices. Blended learning also describes learning that mixes various event-based activities, including face-to-face classrooms, synchronous online learning, and self-paced learning. There's no single formula that guarantees learning and in most cases a variety of learning strategies are developed in a course or learning event.

Ultimately, "[the] optimum choice and mix of these methods is based on the target audience, the content to be learned, and the availability of technologies" (Gagné et al. 2005, 225). In other words, the success of blended learning not only requires practitioners to know how to select and combine different learning technologies, strategies, and methods to achieve effective learning in each individual learner, but also to be keenly aware of what each learner is like and what they already know, what they need to learn, and how they will learn. Thus, the burden of knowing what works best is on instructional designers and educators—and this is the main issue with blended learning. The other significant problem with blended learning is that it lacks "the ability to capture knowledge over a period of time and then make it available in a just in time fashion" (Battersby 2002, cited in Gagné et al. 2005, 225). However, e-learning is seen as a way to address this issue.

E-learning is "formally defined as electronically mediated asynchronous and synchronous communication for the purpose of constructing and confirming knowledge" (Garrison 2011, 2) and is learner-centred (Huffaker and Calvert 2003, 326). It relies on the Internet and related communication technologies to function, and typically occurs in one of two forms: online learning or blended learning (Garrison 2011, 2). In terms of online learning, e-learning is considered a form of distance education. The majority of e-learning, however, occurs as blended learning. Garrison cautioned against using e-learning as a replacement for face-to-face educational experiences (3). This is supported by Gagné et al. who noted, "Stanford University increased student retention in their e-learning program by adding live events to motivate learners to complete self-study materials on time." (Gagné et al. 2005, 225)

Game-based learning is a more recent development and is perceived as the culmination of e-learning and play-based learning. Salcito (2012) suggested that game-based learning would allow "the incentivisation of learning in general". This view seems to have gone mainstream, with schools around the world introducing video games into classrooms (Darvasi 2014) and a surge of research into the efficacy of game-based learning. In the US alone, research into game-based learning is receiving significant funding from "[companies] and foundations like the Bill and Melinda Gates Foundation, the MacArthur Foundation, the Educational Testing Service

(ETS), Pearson, Inc., Electronic Arts (EA), and the Entertainment Software Association (ESA)" (Shapiro 2014). One recipient of such funding is GlassLab (the Games and Learning Assessment Lab), a lab run by the Stanford Research Institute (SRI) that works with external providers "to design and develop state-of-the-art, game-based formative assessments … in response to the climate of student disengagement that currently exists in many classrooms" (SRI International 2016). The Institute of Play is one such provider. "At the core of the experiences we design are games, play and the principles that underlie them," it declares on their website (Institute of Play 2015).

Conflicting views on technology

The other major concern in relation to learning and technology is that there are often conflicting views between researchers, as well as between learners and educators. These views largely centre on three key areas: the 'digital native' phenomenon, digital technology use in education, and the effects of digital media use and exposure.

The 'digital native' phenomenon

According to a census conducted by non-profit U.S. organisation Common Sense[78], American teenagers spend about nine hours a day using media for leisure, not including time spent using media at school or for homework (Wallace 2015). The same report also found that tweens (aged 8 to 12 years) spent about six hours a day on average. "It just shows you that these kids live in this massive 24/7 digital media technology world, and it's shaping every aspect of their life. They spend far more time with media technology than any other thing in their life," said the CEO of Common Sense, James Steyer (Wallace 2015). This phenomenon has led to these young people, who have never known a world devoid of digital technology, to become described as "digital natives" (Prensky 2001), "the net generation, the Google generation or the millenials" (Helsper and Eynon 2010), amongst others. Marc Prensky, the creator of the term "digital natives" (Prensky 2001), proposed that there are marked differences between those born into the present-day digital world and those who are merely "immigrants":

> Digital Natives are used to receiving information really fast. They like to parallel process and multi-task. They prefer their graphic before their text rather than the

[78] According to the Common Sense website, Common Sense is the United States' "leading independent non-profit organization dedicated to empowering kids to thrive in a world of media and technology". (Common Sense 2018)

> opposite. They prefer random access (like hypertext). They function best when networked. They thrive on instant gratification and frequent rewards. They prefer games to 'serious' work. (Prensky 2001, 1)

There has been some debate on the validity of Prensky's claims. Following Prensky's essay, there have been studies confirming Prensky as well as contradicting him (Bennett, Maton and Kervin 2008; Helsper and Eynon 2010; Kennedy et al. 2008). Others highlighted deficiencies in limiting digital users to only two groups (Salajan, Schönwetter and Cleghorn 2010). Although there is no definitive proof regarding digital natives, to an extent a divide does exist. One major issue relating to this divide is that educators and students often view and use technology differently. Li examined student and teacher views about technology and found that there was a marked difference between their views: "In the themes identified in this study, the views of students and teachers were almost always polarized [sic]" (Li 2007, 391).

Similarly, Ben-David Kolikant's (2010) study on digital natives' beliefs about the Internet and its influence on their learning ability found that students who were digital natives had different value systems from those who were not digital natives (e.g. teachers). He noted that "students interviewed for this study appeared to be living within two different value systems" and this negatively influenced "their perceptions of school and learning". These students expressed a preference for using the Internet over tools such as encyclopedias, but ironically this also resulted in them believing they were less effective learners who were "less developed or less successful learners than those who did not have these 'shortcuts'". (1390) This study appears to support Prensky's view that digital natives are more proficient—and therefore more comfortable—in a digital environment. It stands to reason that if students have a higher level of mastery over digital technology than books, they would most likely choose the former over the latter since the digital world feels more familiar (and thus 'normal') to them.

Digital technology use in education

The conflicts relating to the use of digital technology in education have been divided into the the following three topics for discussion: technology adoption; virtual reality and learning; and technology and the future.

Technology adoption

The two most common responses to technology adoption are both problematic. The first is where educators are resistant to the use of digital technology. The lack of acceptance by educators can be an impediment to the success of technology adoption in schools. This is not unique to education. It happens with technology adoption relating to information systems as well, where the "lack of user acceptance has long been an impediment to the success of new information systems" (Davis 1993, 475). Li described this as the 'oversold and underused' phenomenon, in which "computers have been installed in almost all schools but many teachers have not used them" (2007, 390).

The second is where educators do the complete opposite, and insist on using technology at all costs, without considering whether it is necessary or appropriate. The focus on the technology at the expense of the content or context generally occurs when we forget that technology is merely a tool, a medium. Sometimes this can happen because we are distracted by the novelty and features of a technology, at other times it can happen because we default to what we know and what is familiar or expected. With iPads, for example, there is a tendency to equate iPads with other media, or to see iPads as a replacement for other media (rather than as tool to complement them).

Tom Daccord, co-author of the book *iPads in the Classroom: From Consumption and Curation to Creation*, explained this in his article "5 Critical Mistakes Schools Make With iPads (And How To Correct Them)" (Daccord 2012). Some teachers see the iPad as a replacement for a textbook, or as a repository for content, so they try to find subject-specific apps to use on the iPad. However, this focus on content treats the iPad as just another content-delivery medium. Other teachers see iPads as replacements for computers, and get frustrated when they fail to provide the same functionality as a computer. Daccord emphasised that the use of iPads in schools should take advantage of the iPad's ability to enable "consumption, curation, and creativity", all of which are possible using primarily "only four general apps: an annotation app, a screencasting app, an audio creation app, and a video creation app"[79] (Daccord 2012).

Instead of focusing on technology (whether because of its novelty or familiarity), it is better to focus on the actual goal at hand: to create a learning experience through which new knowledge can be learned. Focusing on designing for a learning experience first, and only thinking about whether technology is needed after this is done, is more likely to produce a suitable and successful learning experience. Essentially, the use of technology should be purposeful and not gratuitous.

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[79] According to Daccord, these are the only apps used in the iPads in the Classroom summer workshop at Harvard University.

Virtual reality and learning

The advent of virtual reality has changed the educational landscape. It offers an alternate space in which learning experiences can occur, while at the same time affecting how we experience the real world. This has implications not only in societal and play-based contexts, but also in relation to work and educational contexts as well. In order to understand these implications, it is necessary to first discuss the concept of virtual reality. Virtual reality is often seen as an alternate reality, or an alternative to real-world reality, but Mitchell suggested that this is simply "an illusion" (Mitchell 2015, 44). The separation of these into two different realities—the physical, real-world reality and the digital, virtual reality—is what Jurgenson (2011) called 'digital dualism'. Mitchell critiqued digital dualism for its disregard of "the consequences it has for us right here in this reality, the *only* reality" (45, emphasis in the original), but noted that there are significant differences between our subjective experiences in each reality:

> We still live in [an analog] reality, but the rules of it have changed suddenly. We've extended it and layered new kinds of experiences on top of it. When our friend taps us on the leg through our phone, she makes physical contact with the real you. But she doesn't feel your leg; she feels cold glass. You don't feel the tap of her fingers; you feel a sharp mechanical buzz. (46)

This is largely because although computer and digital technologies have improved dramatically over the last few decades, they still fall short of real life. Online interactions do not allow for the range of nuances afforded by body language and facial expressions and is, according to Mitchell, the reason it is "hard to design social software" (47). But this might change in the near future. There are those who belive that virtual reality will eventually be able to compete with the real world. Philip Rosedale, founder of the online virtual world SecondLife, commented that with devices such as the Oculus Rift headset and low-latency[80], real-time motion-tracking devices from companies such as Sixense and PrioVR, "We won't just be able to see these worlds—we'll be able to touch them" (Rosedale 2014). Rosedale also predicted that virtual reality has the potential to "disrupt and restructure many different basic human exchanges that have nothing to do with playing games" (e.g. "talking face-to-face, working together, or designing and building things") and that if it is able to succeed at this, "the real world will suddenly have real competition" (Rosedale 2014)[81].

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[80] When a device is low latency, any delay between input and output when using the device is unnoticeable by human users of the device. From the user's perspective, this means the device feels as though it is responding in real-time, without any 'lag'. ('Lag' is the colloquial term used by online gamers to refer to the noticeable delay between a player's action and a device/software/server's reaction).

[81] It is worth noting that Rosedale may not be completely objective since he is currently the CEO and co-founder of High Fidelity, a start-up focused on rich interactions between avatars in a virtual world.

There is some evidence that appears to support Rosedale's claim. Media articles have been written about players whose real-world reality has been merged with or superseded by virtual reality. These players spend real-life money to purchase virtual items for use in SecondLife and other online video games (Chung 2015; Lagorio 2006; Rosenwald 2010), and end up in real-life court cases involving disputes over virtual land and murders relating to disagreements over virtual possessions (Lagorio 2006). These examples clearly illustrate that there is some basis for Mitchell's criticism of digital dualism—that separating the virtual from the real is foolhardy, since events that occur in virtual worlds can still have real-world consequences.

Of greater concern here is that this tension between the real and the virtual is not limited to gaming or social contexts—it is equally pertinent in the workplace and in education. Experts across industries have observed a loss of hands-on, real-world skills as more people embraced digital technology and virtual experiences. The lead on Britain's nuclear fusion program, physicist Steven Cowley, observed, "We have a big uptick in engineers and physics students coming in, but we don't have good experimentalists with a feel for what's going on, because they've lost the practical skills." (Clynes 2015, 129) Apple's head designer, Jonathan Ive, made a similar remark at an event at London's Design Museum. "So many of the designers that we interview don't know how to make stuff, because workshops in design schools are expensive and computers are cheaper. That's just tragic, that you can spend four years of your life studying the design of three dimensional objects and not make one," he said, adding later, "how on earth can you do that if what you're responsible to produce is a three dimensional object?" (Winston 2014)

The same thing is happening in education. Real-world educational experiences are increasingly being replaced with virtual ones, as MOOCs (massive open online courses) and MUVEs (multi-user virtual environments) become more and more popular (Waldrop 2013). With the rapid evolution of technology, it is now possible to learn practical skills—such as laboratory work—online. Open University currently offers online courses featuring laboratory work, through its OpenScience laboratory, where students are able to "collect real data from remotely controlled instruments" and "explore real data with simulated instruments such as the virtual microscope". Stanford University's Transformative Learning Technologies Lab also offers digital lab courses, one of which "uses remotely controlled instruments at a centralized [sic] biology lab", allowing students to direct a robot to perform a task and watch it being done via a camera. (Waldrop 2013)

However, the shift to virtual-based learning is not being universally embraced. Waldrop (2013) noted that online video lectures cannot "give students experience in planning an experiment and analysing data, participating in a team, operating a pipette or microscope, persevering in the face of setbacks or exercising any of the other practical and social skills essential for success in science". Others have emphasised the importance of hands-on, real-world experiences in learning, particularly in relation to learning practical skills. "Human beings learn best by exploring or investigating, not by ingesting and swallowing facts and figures," said Nikhil Goyal[82] (Clynes 2015, 127). Computer scientist Ted Selker[83] said that "[something] important is lost when kids don't have—or don't take—the opportunity to explore the world with their hands" (128), declaring that some real-world experiences cannot be replaced by virtual or digital ones:

> Every time we touch a piece of bendy aluminum or soft copper, our brain builds a library of the physicality of that object, and the possibilities for it. The ability to learn conceptually and not just procedurally is created by the process of taking things apart and building things; that's how we develop the intuition to make useful and creative connections. (Selker, quoted in Clynes 2015, 128)

For now, it is still too early to tell whether one is better than the other. On the one hand, there are examples where before-and-after assessments of students suggest that virtual internships can "sustain students' confidence and enthusiasm" (Waldrop 2013). On the other, the shift away from real-world experiences to virtual experiences may be making STEM careers seem less appealing: "Science without interactive labs or projects that relate to students' real-world experiences just isn't that much fun and may be contributing to the declining interest in STEM careers" (Clynes 2015, 127).

Eschewing one for the other does not really make sense anyway—to do so would be an overly simplistic solution to a complex issue. Our interpretation of hands-on, real-world experiences needs to be inclusive of both the real and virtual worlds. After all, virtual worlds are now part of the real world we live in, whether or not they are an alternative to it (Kotler and Edwards 2014)[84]. Furthermore, we should not discount those who "want to build something purely digital that's ambitiously new and different" (Carlson, quoted in Clynes 2015, 128) in favour

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82 Goyal's book, *One Size Does Not Fit All: A Student's Assessment of School*, was released in 2012, when he was just 17 (Swallow 2012).

83 Ted Selker is known for "inventing the TrackPoint device for IBM's ThinkPad and for his user-interface innovations at MIT's Media Lab". He "believes there's no way for someone to full develop creatively by just staring at screens and tapping at keyboards" (Clynes 2015, 128),

84 In fact, some people prefer the virtual world than the real world (Davis, Tienabeso, and Small 2010).

of those who are building real world objects, or vice versa. Rather, we should strive to achieve a happy medium between the real and the virtual. Such an approach would be the most beneficial to the development of learning experiences.

Technology and the future

The uncertainty surrounding the future of technology makes it difficult to decide how and if technology should be used in educational contexts. Research suggests that the resistance to technology adoption is partly due to the fact that change is happening so rapidly that educators are unable to keep up (Chen 2010; Hermans et al. 2008; Mueller et al. 2008). This inability to keep up with the pace of technological change is one purported reason why the use of technology in schools often lags behind our day-to-day use of technology. It is also an obvious flaw if the purpose of education today is to prepare students for the workplace. However, it is difficult to determine how technology should be introduced and used in schools if there is the lack of consensus regarding the use of digital technology and research on digital technology use in classrooms is inconclusive (Blackwell et al. 2013; Ifenthaler and Schweinbenz 2013).

The uncertainty regarding the future of Web 2.0[85] is another contributing factor. The future of Web 2.0 is of significant consequence because it has a bearing on the decisions relating to the selection of technologies for integration into the curricula of any given education system. If governments and schools are going to invest time and money into purchasing and implementing technologies, it is not enough to look solely at technological features. In the long term, qualities such as longevity and permanency, and logistical issues such as maintenance and technical support, are crucial and must be taken into account as well. Otherwise, the implementation and maintenance of technology in education will be difficult and costly. As Anderson (2007, 51) declared, "Does this matter to education? The answer is yes, if too much time, resources and data are invested in new and untested applications which are not subsequently supported adequately or are backed by companies that eventually fail."

Effects of digital media exposure and use

The last main area of contention relates to the effects of digital media. Many digital media technologies—including devices such as tablets and smartphones, mobile applications such as Facebook and Instagram, etc.—are still relatively young; most have been around for less than a

[85] There are speculations about whether Web 2.0 will evolve into what Anderson (2007) referred to as the Semantic Web.

decade. (To put things in perspective, the World Wide Web has only been around since 1989.) As a result, there is a lack of evidence based on longitudinal research and we are still unable to determine—with any kind of certainty—the long-term effects of exposure and use. Of particular interest here is the conflict relating to the use of digital media by children and youth, since education typically involves these two groups. There are arguments both for (Greenhow and Robelia 2009; Marsh 2005; Smith 2002; Yelland 2007) and against (American Academy of Pediatrics 2013; Rowan 2015) the exposure of children to digital media. Greenhow and Robelia (2009) suggested that lack of exposure could disadvantage children growing up in world that is becoming increasingly dominated by digital media. Marsh (2005) considered media technology to be a helpful tool in the social and personal development of children. Smith (2002) observed that technology used during play provided a higher level of engagement and learning. Yelland (2007) believed that technology use allowed for greater access to learning experiences and expanded thinking methods.

As for the negative effects of digital technology on children, there is no conclusive scientific evidence of this as yet, although studies are currently being carried to determine the effects of mobile and smartphone use (if any) on teen brain development and on adult health in the long term (Glatter 2014). There are some (Rowan 2015) who are concerned about the negative impact of excessive technology use. This appeared to be supported by the American Academy of Pediatrics (AAP), which previously recommended that parents limit entertainment-related screen time to less than two hours per day and to avoid screen media exposure to children under the age of two (American Academy of Pediatrics 2013). In September 2015, however, the AAP changed the guidelines to "reflect a more nuanced approach" (Shapiro 2015). The AAP's more balanced approach to digital technology acknowledges the impracticality of eschewing the real for the virtual or vice versa.

Since there is no definitive evidence that learning in a digital environment is more beneficial, it is no wonder many educators choose to play it safe and stick with what they know. Overall, however, the consensus seems to be that digital experiences should not completely replace real world experiences; they need to be balanced with a variety of real world experiences (CIO 2003; Hatch 2011; Hunter 2014; Taylor 2012). Thus, until proven otherwise, it would seem that moderation is key.

Emotion

This section is divided into two main parts. “Emotion, movement, thought, and our senses” looks at the relationships between emotion, movement, thought, and sensory perception. It begins by looking at the relationship between thought and sensory perception, and how these affect and are affected by movement. It then discusses the idea that emotion at the centre of everything we do. “Emotion, learning, and aesthetics” reviews the research relating to the relationships between emotion, learning, and aesthetics. Emotion and learning, emotion and aesthetics, and learning and aesthetics are each discussed as separate pairs, then all three are examined collectively.

Emotion, movement, thought, and our senses

Technological developments have not only allowed neuroscientists to further their understanding of the workings of the human brain with regard to language and visuals, they have also facilitated a renewed interest in the relationships between our mind, body, emotions, and senses. The work of neuroscientists Patricia and Paul Churchland, as well as Antonio Damasio, sheds some light on how this occurs. They all found that conscious thought—and the cognitive activity that allows it—cannot be easily separated from the senses or from emotion. Paul and Patricia Churchland saw the mind and the brain as inextricably connected, and thus proposed that the philosophy of the mind could not be discussed without knowing how the brain works[86] (MacFarquhar 2007).

Damasio (2008) looked at the connection between the body and the brain, challenging the idea that the body and the brain be viewed as separate entities:

> Despite the many examples of such complex cycles of interaction now known, body and brain are usually conceptualized as separate, in structure and function. The idea that it is the entire organism rather than the body alone or the brain alone that interacts with the environment often is discounted, if it is even considered. Yet when we see, or hear, or touch or taste or smell, body proper and brain participate in the interaction with the environment. (Damasio 2008)

86 The work of Paul and Patricia Churchland straddles neuroscience, psychology and philosophy. They have, together and separately, worked on unravelling the mysterious relationship between conscious experience and the brain. To the Churchlands, "The mind wasn't some sort of computer program but a biological thing that had been cobbled together, higgledy-piggledy, in the course of a circuitous, wasteful, and particular evolution." In their interdisciplinary study of neuroscience and philosophy—generally referred to as neurophilosophy—they attempted to illustrate how the mind does what it does, moving beyond philosophy's approach of simply speculating about what it does. (MacFarquhar 2007)

This suggests that thinking not simply a response to sensory input, which is then output as a behavioural response. It also contradicts the behaviourist approach that underlies much of HCI and instructional design.

Viewing the body and brain as integrated parts of a whole organism requires a closer examination of the relationship between visuals, thought, and movement. Let us first look at visuals and thought. *The Stanford Encyclopedia of Philosophy* refers to the notion of mental imagery as a means of representation:

> On a more consensual note, with only rare exceptions (e.g. Wright, 1983; Martin, 2008 p. 160) nearly all serious discussions of imagery take it for granted that it bears intentionality in the sense of being of, about, or directed at something (Harman, 1998): A mental image is always an image of something or other (whether real or unreal), in the same sense that perception (whether veridical or not) is always perception of something (see Anscombe, 1965). It is in virtue of this intentionality that mental imagery may be (and usually is) regarded as a species of mental representation that can, and often does, play an important role in our thought processes." (Thomas 2014)

This complex relationship between visuals and thought has been the subject of much contemplation for centuries. Greek philosopher Aristotle, for instance, "held that mental images are like inner pictures," and that these "mental images … resemble or copy what they represent" (Tye 1991, 2). The assumption was that if "real pictures must resemble what is pictured and not just represent it by playing a conventional symbolic role", then "if mental images are inner pictures, they must represent in like fashion" (Tye 1991, 2). Some translations of Aristotle's work also suggest that he believed "mental images are crucial to all thought" (Tye 1991, 3).

The French philosopher René Descartes also wrote about mental images. Notably, Descartes differentiated between imagination and thought (or conception), suggesting that imagining something required the creation of a detailed mental rendering, whereas thinking (or conceiving) involved coming up with the notion of it. Thus, we can imagine a five-sided shape (and 'see' it in our mind), but we can only conceive of a 1000-sided shape because the mental image we 'see' does not accurately feature 1000 sides, even though we still have a notion of what 1000 is. (Tye 1991, 3) Descartes also considered ideas to be "thoughts that 'are, so to speak, pictures'", unlike percepts which "proceed from certain things outside us". Like Aristotle, Descartes believed that "percepts (and mental images) copy objects in the external world". (Tye 1991, 4)

Thomas Hobbes, an English philosopher, believed that the mental image we conjure of something we have seen is "more obscure" than what we see at the time of viewing and that this mental image becomes "weaker" as time passes (Tye 1991, 4-5). In addition, Hobbes thought it was possible to imagine things even if they had not been seen before, simply by combining separate mental images of things that had been previously seen:

> Again, imagination being only of those things which have been formerly perceived by sense, either all at once or by parts at several times, the former, which is the imagining the whole object as it was presented to the sense, is simple imagination, as when one imagines a man or horse which he has seen before. The other is compounded, as when, from the sight of a man at one time and of a horse at another, we conceive in our mind a centaur. (Hobbes, quoted in Tye 1991, 5)

Finally, there are the empiricists, John Locke, George Berkeley and David Hume. Each of them assumed that all thought is constructed from a basic set of images that are derived from sensory experience, which are then manipulated or combined to build more complex images (Tye 1991, 5). Locke, specifically, believed "memory is taken to consist in the retention of images" and "learning a language is taken to consist in associating sounds and images" (Tye 1991, 5).

Interestingly, amidst all the debate on language versus images, there is an obvious lack of attention given to other sensory modes besides the visual. Mitchell (2005, 257) wrote about this bias, highlighting that "all the so-called visual media turn out to involve the other senses (especially touch and hearing). All media are, from the standpoint of sensory modality, 'mixed media'". Earlier, it was suggested that one reason for the dominance of language over images might have been the limitations of technology. Perhaps the same could also be said of the dominance of visual modes of communication (which includes both images and written or printed text). In other words, the emphasis on the visual in communication and in media can partly be attributed to the lack of tools that allow us to replicate, record in, or use any of the other sensory modes. For example, early historical records tended to be visual because it was difficult (or impossible) to make permanent recordings of other senses. However, this did not mean that the other senses were less important in the exchange of information or learning. Improvements in technology are changing this. For instance, the development of touchscreen and haptic technology has given the touch sensory mode greater significance.

Indeed, as technology continues to move forward, other sensory modes may assume greater importance. The Smell-O-Vision for the virtual reality headset Oculus Rift, for instance, attempts to engage the olfactory sensory mode. Spike Jonze's movie *Her* featured auditory-based technology, described by Vanhemert as "a novel form of augmented reality computing" that is not only invisible, but also "less intrusive, less demanding"—it is "dissolved into everyday life" (Vanhemert 2014). Even though these technologies have yet to become mainstream, in order to future-proof discussions about the relationship between visuals and thought in the future, it makes sense to view the visual as one of fives modes[87] of sensory perception, and speak more generally of the relationship between sensory perception and thought (as shown in Figure 4).

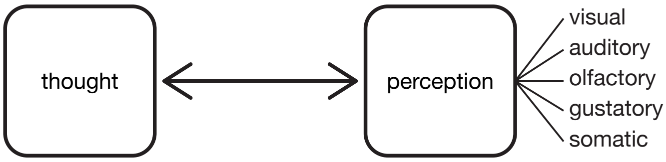

Figure 4: Relationship between thought and perception

However, even when sensory perception and thought are considered together in the context of human experience, it is apparent that something is still missing. That something is movement (see Figure 5). On one hand, movement is often needed to acquire the sensory input necessary for perception to occur. At other times, it is a response to sensory input and thought combined. In the context of design and human factors[88], Weinschenk (2011, 65) referred to the relationship between cognition, motor movement, and sensory perception (focusing solely on the visual): "The theory is that there are basically three different kinds of demands or loads that you can make on a person: cognitive (including memory), visual, and motor". She explained that "[each] load uses up a different amount of mental resources", with cognitive loads being the most demanding, followed by visual, then motor loads.

There is also evidence to suggest that movement also affects thought and cognitive ability (Cotman, Berchtold and Christie 2007; Hamblin 2014; Jensen 2005; Ratey 2012). Cotman,

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[87] There is ongoing debate about the number of modes of sensory perception and what these should be (Jarrett 2014). However, in this context, the five basic modes we are familiar with—sight, sound, taste, smell, touch—will be used.

[88] According to the International Ergonomics Association, "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." (International Ergonomics Association 2015)

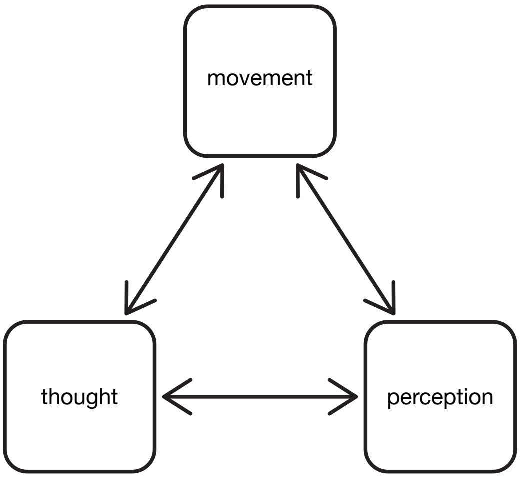

Figure 5: Relationship between thought, perception, and movement

Berchtold and Christie observed that evidence strongly suggests exercise can improve learning and memory in people, although little is still known about "the types of learning that are improved with exercise" (2007, 465). Hamblin (2014) referred to several studies that found a link between physical activity and improved cognitive function (Hoza et al. 2015; Pontifex et al. 2013; Smith et al. 2013). Hoza et al. (2015) found that physical activity produced positive effects on the mood and behaviour of children, regardless of whether they had ADHD (Attention Deficit Hyperactivity Disorder). Pontifex et al. (2013) found that exercise improved working memory in children with ADHD, as well as the ability to maintain focus and switch between tasks. Brain scans of the children who exercised showed greater capacity for processing and mental workload compared to those who did not exercise (Hamblin 2014). Smith et al. (2013) pointed to earlier research by Hall, Smith, and Keele (2001) and Kramer et al. (1999), which found a link between physical activity and the preservation and enhancement of cognitive function. They also observed that there was research indicating the existence of a potential link between physical activity and improved academic performance.

Jensen (2005) stated that "all motor activity is preceded by quick thought processes that set goals, analyze variables, predict outcomes, and execute movements" and that this, in turn, "requires widespread connections to all sensory areas". He outlined research that showed evidence of a relationship between movement and cognitive function:

> Various studies support the relationship between movement and the visual system (Shulman et al., 1997), movement and the language systems (Kim, Ugirbil, & Strick,

> 1994), movement and memory (Desmond, Gabrielli, Wagner, Ginier, & Glover, 1997), and movement and attention (Courchesne & Allen, 1997). These studies do not suggest that there is movement in those functions. But they suggest a relationship with the cerebellum in such mental processes as predicting, sequencing, ordering, timing, and practicing or rehearsing a task before carrying it out. The cerebellum can make predictive and corrective actions regardless of whether it's dealing with a gross-motor task sequence or a mentally rehearsed task sequence. In fact, the harder the task you ask of students, the greater the cerebellar activity (Ivry, 1997).

Finally, Ratey (2012) described examples where the introduction of movement programmes in schools helped to enhance students' attention and learning ability.

Collectively, the research outlined above provides support for the idea that there is a close relationship between sensory experience, movement, and thought. At the same time, underlying all of these is a single, common factor: emotion. Such a claim would, at one time, have been met with opposition, but this is no longer the case. As Weiss observed, "recent research conducted by neurologists and educators shows a strong link between emotion and reason, feelings and thoughts" (2000, 45). Weiss also noted, "Emotion drives attention, which drives learning, memory, and problem-solving behavior [sic]. Simply stated, learning doesn't take place when there's no emotional arousal." (46) In the same vein, Damasio wrote:

> Emotions are inseparable from the ideas of reward and punishment, pleasure and pain, approach and withdrawal, personal advantage and disadvantage. In organisms equipped to sense emotions—that is, to have feelings—emotions have an effect on the mind, as they occur, in the here and now. Emotion is dedicated to an organism's survival. (Damasio, quoted in Weiss 2000, 45)

The connections between emotion, cognition, motor movement, and sensory perception have also been recognised in other disciplines. In the context of media literacy, Potter (2008, 20) categorised information into four dimensions: cognitive, emotional, aesthetic, and moral. Potter referred to the cognitive dimension as "that which resides in the brain" and the emotional dimension as "that which lives in the heart" (i.e. information about feelings), while the information in the aesthetic dimension was referred to as "that which resides in our eyes and ears". The moral dimension contains "information about values" that allow us to judge between right and wrong. Potter stated that the information we acquire from media use must come from all of these four dimensions. Thus, given that recent findings highlight the central role emotion plays in both cognition and behaviour, it seems appropriate to place emotion at the centre of the thought-movement-perception cycle (see Figure 6).

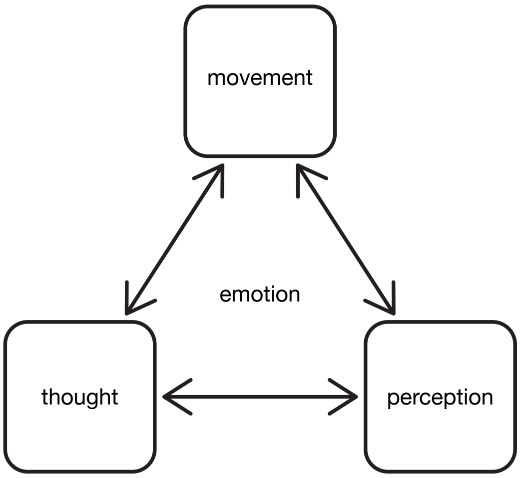

Figure 6: Relationship between thought, perception, movement, and emotion

Emotion, learning, *and* aesthetics

Here the relationships between emotion and learning, emotion and aesthetics, learning and aesthetics, are first explored separately in clusters. Emotion and learning is first discussed in the contexts of education, HCI, instructional design, and psychology. Then, the relationship between emotion and aesthetics is briefly addressed. This is followed by a review of the research on learning and aesthetics. Finally, emotion, learning *and* aesthetics are looked at collectively in the concluding section.

Emotion and learning

Emotion plays a crucial role—not only in sensory perception and thought, but also in learning. The ancient Greeks were certainly aware of this and used it to great effect. In particular, they used emotion to aid memorisation , having realised that "striking and unusual images" images that provoke a strong emotional response are far more effective at promoting information retention and recall (Yates 2014, 25-26). The notion that learning is both an "affective as well as cognitive" process was proposed in academia as far back as the 1970s (Boy and Pine 1999, 221). More recently, social constructivists recognised that emotions could improve learning (Op 'T Eynde, de Corte, and Verschaffel 2006). They focused on "how learners interact to construct new knowledge" (McMahon 1997, quoted in Napierala 2011, 13) and thought that fostering an emotional connection between learners could encourage learning.

In the context of HCI, the connection between emotion and learning was not always recognised. The scientific approach used in early HCI research tended to value measurable qualities—like efficiency and usability—over subjective qualities such as emotions and experiences. Consequently, the HCI industry was slow to embrace the study of users' emotions and experience, often dismissing it as being superficial and irrelevant. At the same time, traditional interface designs focused largely on achieving measurable qualities (e.g. efficiency and usability), and on meeting the cognitive and physical needs of users (Tan 2014, 33). Later, once the importance of users' emotional responses was eventually recognised (Laurel 1986; Reeves and Nass 1996, cited in Tan 2014, 34), HCI researchers began to investigate the social and emotional aspects of the user experience (Picard 1997; Picard and Wexelblat 2002; Khaslavsky and Shedroff 1999; Laurel 1991; Norman 2004, cited in Tan 2014, 34).

More recently, connections have been made between measurable qualities (e.g. usability) and more subjective qualities that relate to emotion or affect. For example, Tan (2014, 35) suggested that fun and enjoyment are integral to usability. Wright, McCarthy and Meekison (2005) proposed that "four threads of experience" (46) be considered when designing for an experience: emotional, sensual, compositional, and spatio-temporal. The emotional thread involves emotional engagement. The sensual thread involves sensory perception and engagement. The compositional thread involves thought—"If you are asking questions like; 'what is this about?', 'what has happened?', 'what will happen next?', 'does this make sense?', 'I wonder what would happen if?' then you are thinking about the compositional structure of experience." (47). The spatio-temporal thread refers to the space and time in which the experience occurs.

In instructional design, emotions were also neglected for some time. In *Principles of Instructional Design*, for instance, there is little mention of emotion or affect other than pointing out that future brain research may "provide insight in the future about how emotions affect cognition" (Gagné et al. 2005, 7). This can be attributed to the fact that the models of memory used in Gagné et al. did not make any references to the relationship between emotion and memory. These models, like those in HCI, were systems-based. This means that they centred primarily on the way information is processed and stored, and is based on the view that the human brain processes and stores information much like a computer. Some examples of this include the models by Atkinson and Shiffrin (1968), Craik and Lockhart (1972), and Tulving (Tulving and Donaldson 1972). Atkinson and Shiffrin's model of memory focused on the transfer of information acquired from external stimuli to short-term and long-term memory storage. Craik and Lockhart's levels of processing model considered how processing information at deeper levels (as opposed to shallow levels) resulted in better memory storage. Tulving's model took into account the nature of the information stored in memory and the different kinds of memory used to do so.

The focus on memory and other cognitive processes was a result of the cognitive revolution, which saw interest shift away from "psychological functions and neural mechanisms" toward cognitive processes such as perception and memory (LeDoux 2000). Consequently, for a time research in psychology and brain science became dominated by the cognitive approach, while research into emotion diminished. The shunning of emotion as a topic of interest in cognitive research can be attributed to what LeDoux referred to as "the dark cloud of subjectivity" (156). In a way, this division between emotion and cognition mirrors the aforementioned philosophical separation of art from science that resulted in the view of science as being superior to art[89].

The link between emotion and memory was finally given some attention by a number of cognitive psychologists in the 1980s. Several different network models of memory were produced in succession: Gordon H. Bower's Associative Network Theory (ANT) was published in 1981, John R. Anderson followed with his version of Adaptive Control of Thought (ACT) in 1983, while David E. Rumelhart and James L. (Jay) McClelland published their Parallel Distributed Processing (PDP) model in 1986. Of these, Bower's ANT was used the most frequently in research on emotion (Yates and Nasby 1993). This is likely due to the centrality of emotion in Bower's ANT model. As Yates and Nasby (1993, 308-309) observed:

> Bower's ANT (Bower, 1981; Bower and Cohen, 1982) adds special emotion nodes to associative networks. Emotion nodes in Bower's ANT are defined as central to networks because of the multiple connections they enjoy to many memory nodes. … Emotion nodes, as described in ANT, serve a key role in organizing [sic] memory. Memories are encoded around and in association with the emotion node active at the time of encoding, and activation of an emotion node results in spreading activation to nodes closely associated with it.

However, the recent resurgence of cognitive research relating to emotion can largely be attributed to neuroscience research showed that emotion is "an expression of basic mechanisms of life regulation developed in evolution" and essential for survival (Damasio 2004, 49). Damasio declared that emotions play "a critical role in virtually all aspects of learning, reasoning, and creativity" and possibly even "in the construction of consciousness" (49), while Christianson (2014, xiii) observed that interest in the relationship between emotion and memory has rapidly increased, and suggested that this would be "of key interest for psychological research during the next decade".

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[89] See pages 23–25.

Indeed, this has proved to be the case for the last two decades—many have looked into the connection between emotion and learning. Sylwester (1994) provided a comprehensive overview of how emotions affect learning and offered suggestions for applying this knowledge in classrooms. Brearley (2000) looked at emotions and learning in the context of emotional intelligence and how it relates to the structure of learning. Dong (2007) looked at how aesthetically-pleasing design can produce positive emotions that influence multimedia learning. Tettegah and Gartmeier (2016) collected writings that connected emotion and learning with design and technology in their aptly named book *Emotions, Technology, Design, and Learning*.

Emotion and aesthetics

Separately, there has been investigation into the relationship between emotion and aesthetics. Those working in the arts have studied this relationship for a long time. Stafford wrote that aesthetics has the "capacity to bridge experience and rationality, emotion and logic", highlighting that "from Leibniz to Schiller, the term connoted the integration of mental activity with feeling" (1996, 52). Anderson (2011, 32) emphasised that "how we think cannot be separated from how we feel". Designer Steven Bradley (2010) suggested that our perception of how well an object functions is fuelled by emotion, not logic. He argued, "Aesthetics influence our opinions of products, and we typically find aesthetically pleasing products to be more effective simply by virtue of their aesthetic appeal." Bradley's opinions are partly influenced by cognitive scientist Donald Norman's book *Emotional Design*, which highlighted the role of emotion in our use of—and response to—design.

Norman's recognition of the importance of emotion happened belatedly and, to some extent, his intellectual journey can be said to reflect that of many science disciplines. For example, Norman initially did not give much attention to emotion and aesthetics. (This was—and is—common in many science disciplines.) His early background was in engineering and computer science, disciplines that tended to focus on effectiveness and efficiency. His subsequent shift to psychology and cognitive science led him to develop a more people-centric approach, as these disciplines emphasised the importance of user-centred design and usability. However, for the most part all of these disciplines (e.g. cognitive science, neuroscience, and HCI) treated aesthetics as little more than an afterthought, and generally disregarded the relationship between aesthetics and emotion.

Learning and aesthetics

Similarly, there is a general disregard for aesthetics in relation to learning (and, in particular, instructional design). Brown observed a distinct lack of literature examining aesthetics in relation to "a learning experience, the affective domain or any particular design action" (2010, 24). However, she noted that some did address the link between aesthetic experience and education (e.g. Dewey 1934; Parrish 2005; Parrish 2009; and Wilson 2005). There is existing research on the relationship between aesthetics and learning, but this is focused mainly on the impact of the physical environment on learning (as opposed to the impact of learning materials or content on learning). Some research looked at the effect of the classroom or school environment on student behaviour and learning (Abbas and Othman 2010; Cheryan et al. 2014; David and Weinstein 1987; Guardino and Fullerton 2010; Morrow 1990; Rivlin and Weinstein 1984). These studies found the classroom or school's physical environment had a notable influence on students' behaviour and their learning. Other research examined the effect of the attractiveness of the learning environment on student attitudes (Chan 1988; Maslow and Mintz 1956). Maslow and Mintz (1956, 466) found that students who perceived their environment as beautiful felt "comfort, pleasure, enjoyment, importance, energy and a desire to continue their activity", while Chan (1988) suggested that students are likely to do better in school because they feel more positive in attractive surroundings.

Emotion, learning, *and* aesthetics

Viewed collectively, the existing research on the relationships between learning and emotion, emotion and aesthetics, and learning and aesthetics suggests that learning, emotion, and aesthetics are interconnected. However, research that explicitly discusses the relationship between all three is limited. Of these, only two are sufficiently relevant and worth mentioning. The first is Brown (2010, 46-49), who declared that aesthetics produce an emotional response to learning that can influence attitudes toward learning and affect learning itself: "The heart of the definition of aesthetics in instructional design is characterized [sic] as a learning experience in the affective domain" (Brown 2010, 46). The second is Dong's (2007) investigation into the effect of interface design on learning in a multimedia learning environment. Dong found that "positive emotions enhanced problem solving, consistent with previous studies on the effects of positive emotions" (119), although his findings were not statistically significant. The difficulty experienced in sourcing relevant articles indicates that the relationship between aesthetics, emotion, and learning warrants more research and investigation.

Related visual models

This section reviews and summarises the visual models that are relevant to this research. The models reviewed are Barnard's Interacting Cognitive Subsystems (ICS) framework, Plutchik's wheel of emotions, Dunn's *Sensory Mapping* infographic, McCandless' *Colours in Culture* infographic, and Capturing Unstable Media's interaction model. These visual models were examined to explore the different possible ways of presenting interactivity in the form of a model.

Barnard's Interacting Cognitive Subsystems (ICS) framework

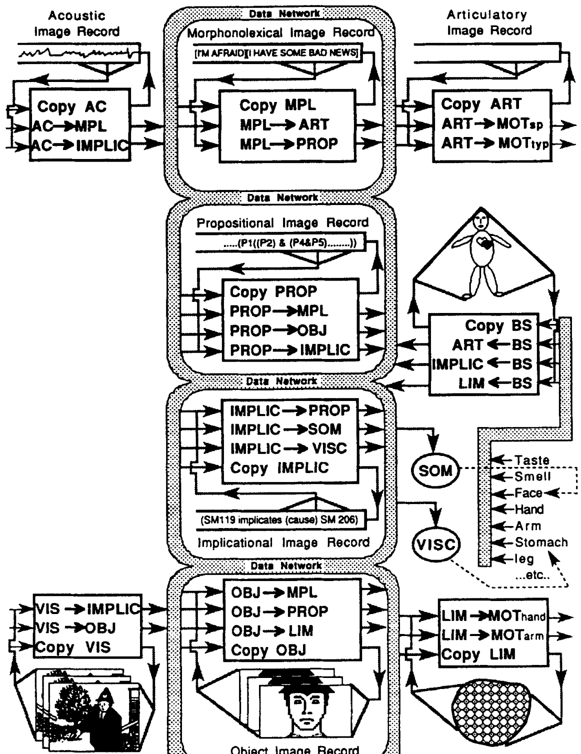

Figure 7: Barnard's Interacting Cognitive Subsystems (ICS) framework (taken from Barnard and Teasdale 1991, 11)

Barnard's theoretical Interacting Cognitive Subsystems (ICS) framework (Figure 7) was intended to illustrate the underlying resources that enable cognition, how they function, and the relationships between them. It also presupposed that cognition and its related functions resulted in the development and production of emotion—"emotion is the result of system-wide activity" (Barnard and Teasdale 1991, 5). The framework consists of nine interacting subsystems that relate to the nine different types of information involved in cognition.

These are divided into two main categories: peripheral subsystems and central subsystems. The peripheral subsystems are further divided into two subcategories. Table 2 shows the distribution of the subsystems across the different categories and subcategories.

Table 2: Categorisation of subsystems in ICS (summarised from Barnard and Teasdale 1991)

<table>
<tr><th colspan="3">Peripheral subsystems</th></tr>
<tr><td rowspan="3">Sensory and proprioceptive</td><td>(1) Acoustic</td><td>Sensory information relating to sound frequency (i.e. what we “hear in the world”)</td></tr>
<tr><td>(2) Visual</td><td>Sensory information relating to the visual (i.e. what we “see in the world”)</td></tr>
<tr><td>(3) Body state</td><td>Other forms of sensory information that are neither visual nor acoustic (i.e. pressure, pain, temperature, taste, smell, etc.)</td></tr>
<tr><td rowspan="2">Effector</td><td>(4) Articulatory</td><td>Movement of muscles relating to “subvocal speech output”</td></tr>
<tr><td>(5) Limb</td><td>Movement of muscles relating to “‘mental’ physical movement”</td></tr>
<tr><th colspan="3">Central subsystems</th></tr>
<tr><td colspan="2">(6) Morphonolexical (MPL)</td><td>What we “hear in the head”</td></tr>
<tr><td colspan="2">(7) Object</td><td>Visual imagery (i.e. what we see in our mind)</td></tr>
<tr><td colspan="2">(8) Propositional</td><td>The awareness or knowledge of semantic relationships</td></tr>
<tr><td colspan="2">(9) Implicational</td><td>Relates to the holistic sense of knowing or feeling that collectively results from the other subsystems (i.e. “schematic models of experience”)</td></tr>
</table>

Barnard and Teasdale (1991, 3–6) outlined and discussed the requirements of the ICS framework, and noted that it should:

- be comprehensive;
- explicitly recognise the way different types of information contribute to the production of emotion;
- reflect the dynamic nature of emotion, which can persist and/or change over time;
- illustrate the production and evolution of emotion in relation to the interaction between subsystems at a local level, as well as the broader patterns of interaction at a global level; and
- indicate the correlation between subjective experience and various aspects of information-processing.

The ICS framework has achieved the above requirements with some success, in particular the level of detail in its representation of the processes involved. Figure 8 shows a comparison between the standard cognitive model used at the time with the ICS framework, with the latter presenting a more thorough interpretation of the way thoughts and images influence emotion. However, as can be seen from the full ICS framework in Figure 7, it is clear that the comprehensiveness of the ICS framework is diminished because of its complexity. Obviously, this is in large part due to the dynamic nature of the framework as well as the number of subsystems involved—simply put, it is because there are so many interactions and patterns occurring in the framework, and these are constantly changing.

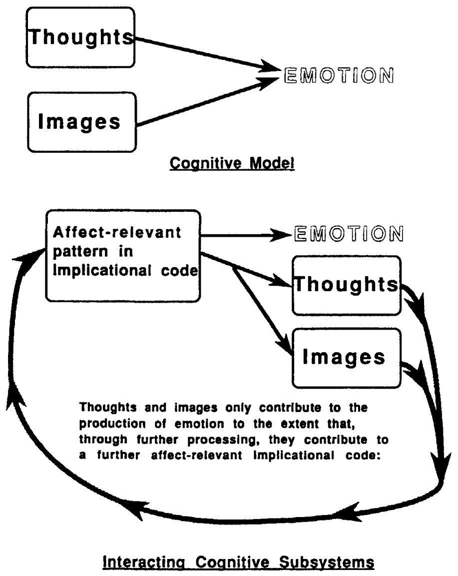

Figure 8: Comparison between standard cognitive model and the Interacting Cognitive Subsystems (ICS) framework (taken from Barnard and Teasdale 1991, 23)

Plutchik’s wheel of emotions

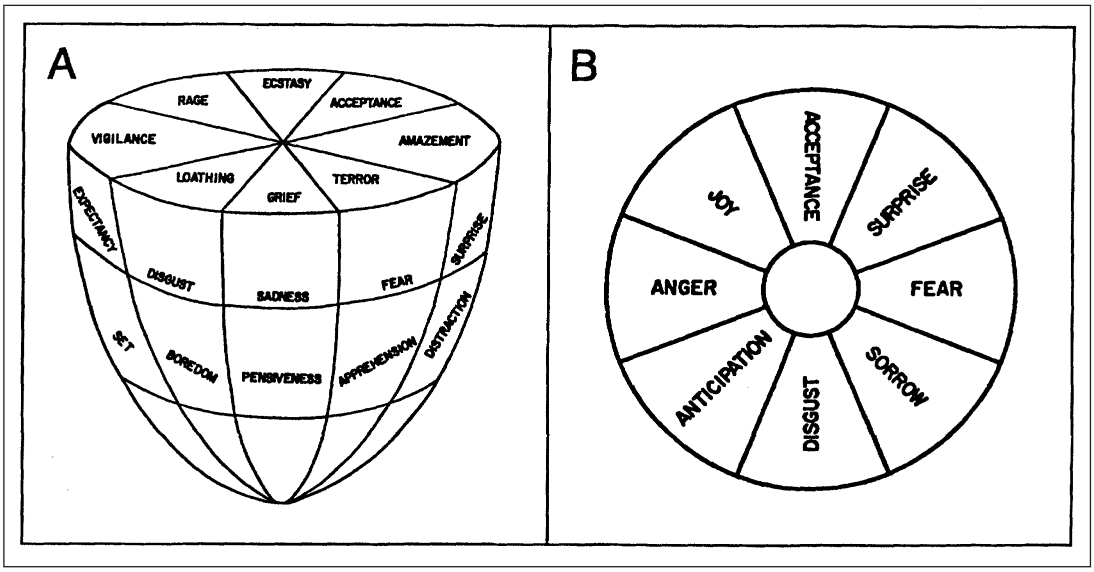

Figure 9: Plutchik’s wheel of emotions (Plutchik 1991, published in TenHouten 1995, 431)

Robert Plutchik’s wheel of emotions (Figure 9) provides a useful starting point when considering affective interactivity. A coloured version of Plutchik’s wheel of emotions is shown in Figure 10. Plutchik first presented his model of emotions in an article in 1958, and elaborated on this in the first edition of *The Emotions: Facts, Theories and a New Model*, published in 1962 (Plutchik 1991, ix). In his model, Plutchik identified eight primary emotions which he thought formed the basis for all other secondary emotions. The range and quantity of different emotions identified by Plutchik is sufficiently large as to be problematic if they were integrated into the model of interactivity. It would result in the model becoming too complex and unwieldy thereby reducing its efficacy as a practical tool for widespread use.

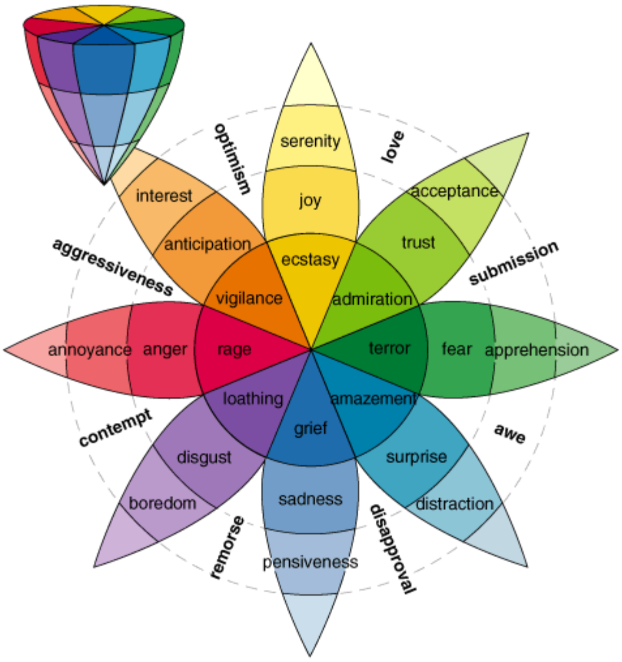

Figure 10: Plutchik's wheel of emotions in colour (Smith 2010)

At the same time, the use of colour is an attribute that is worth considering. Applying colour to the wheel of emotions model made it more visually engaging. Also, by aligning particular colours with related emotions, this contributes toward improving comprehension and increasing the speed of comprehension, making the model more effective. It is expected that similar benefits could be achieved by using colour in the model of interactivity.

Dunn's Sensory Mapping infographic

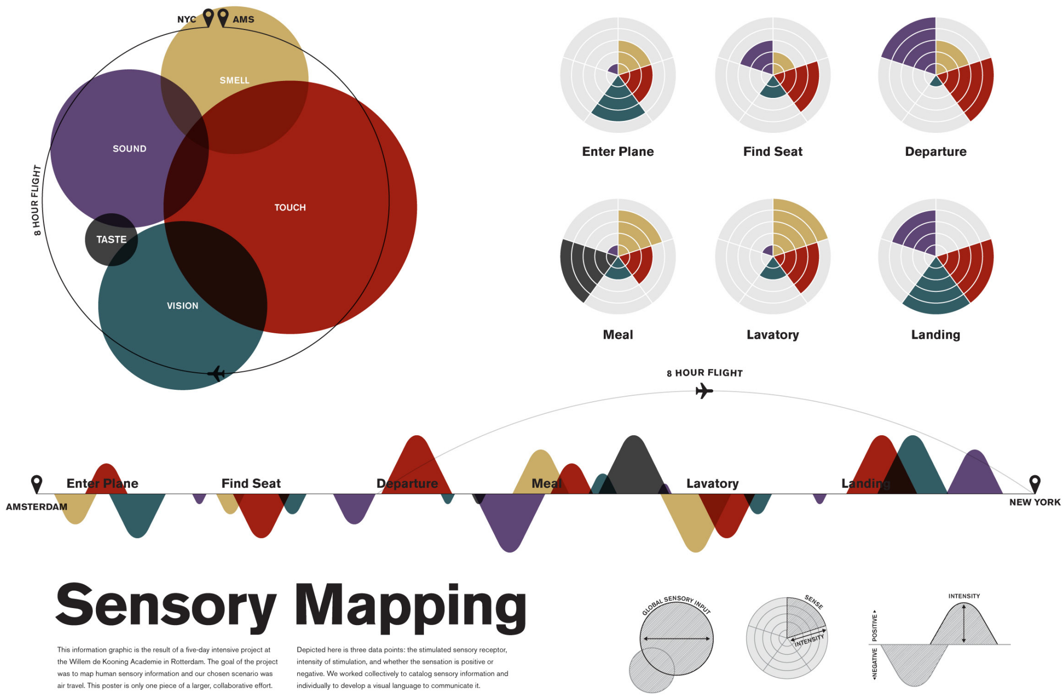

Figure 11: Sensory Mapping infographic by Colin Dunn (Labarre 2010)

Colin Dunn's infographic presents a visual way of mapping the sensory stimulation relating to air travel (Figure 11). It was discovered by chance after the final model was developed, and is included here as a point of interest and comparison. Dunn's infographic maps the five sensory modes that are stimulated (Figure 11, top left), the intensity of the stimulation for each sensory mode in relation to different activities (Figure 11, top right), and whether the stimulation is positive or negative (Figure 11, bottom). It has some similarities with the model of interactivity:

» the sensory modes selected for mapping;

- the circular shape and use of rings in the map on the top right; and
- the use of colour to differentiate between the sensory modes.

It is observed here that a potential improvement for the model of interactivity in future might be to include the level of interactivity or engagement. If so, using a format similar to the bottom map may be one possible method of representing this.

McCandless' Colours in Culture infographic

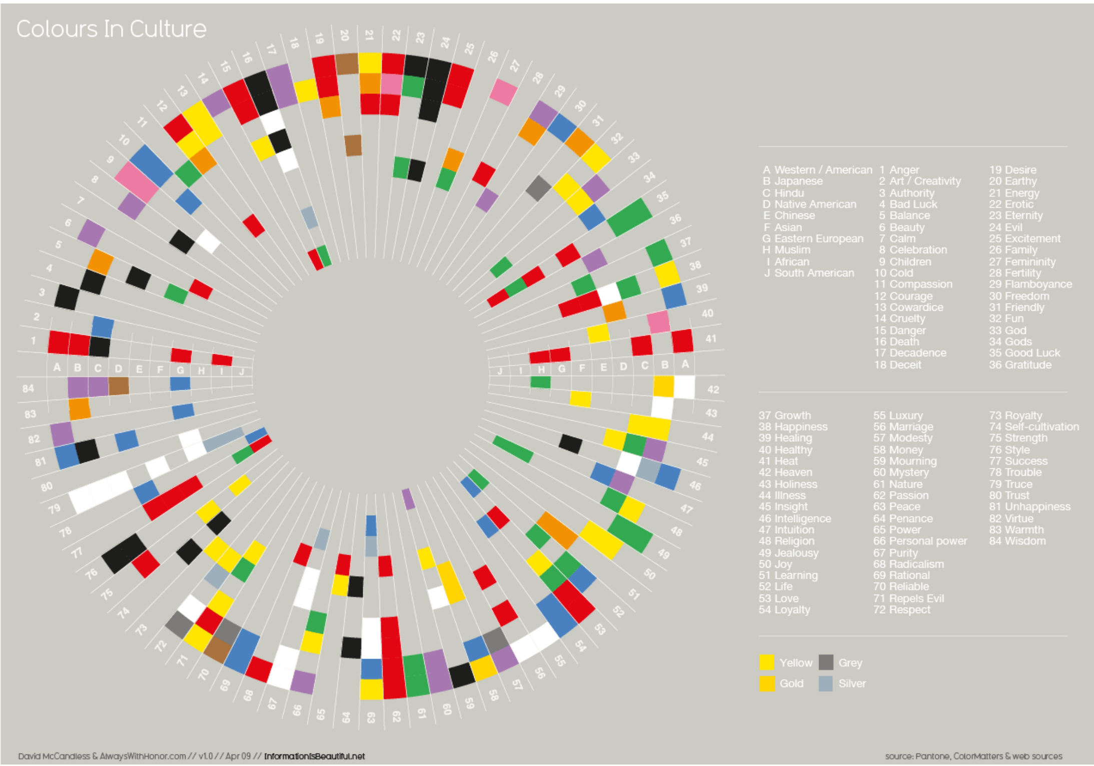

Figure 12: Colours in Culture infographic by David McCandless and AlwaysWithHonor.com (McCandless and AlwaysWithHonor.com 2009)

The Colours in Culture infographic (Figure 12) uses colour and segmentation to show the relationships between culture, colour, and meaning. The position of the segment along the radius of the circle relates to a culture (A to J) and the position of the radial columns around the circle relate to a meaning (1–84). Also included is a key that explains the cultures relating to each alphabet and the meanings relating to each number, as well as the names of similar-looking colours (e.g. yellow/gold; grey/silver). The use of segmentation to show relationships was adopted in the process of developing the final model of interactivity because this method allowed many relationships to be depicted simultaneously. This is useful because it means a single diagram can essentially be used to provide an overview of the relationships between many different factors.

Capturing Unstable Media's interaction model

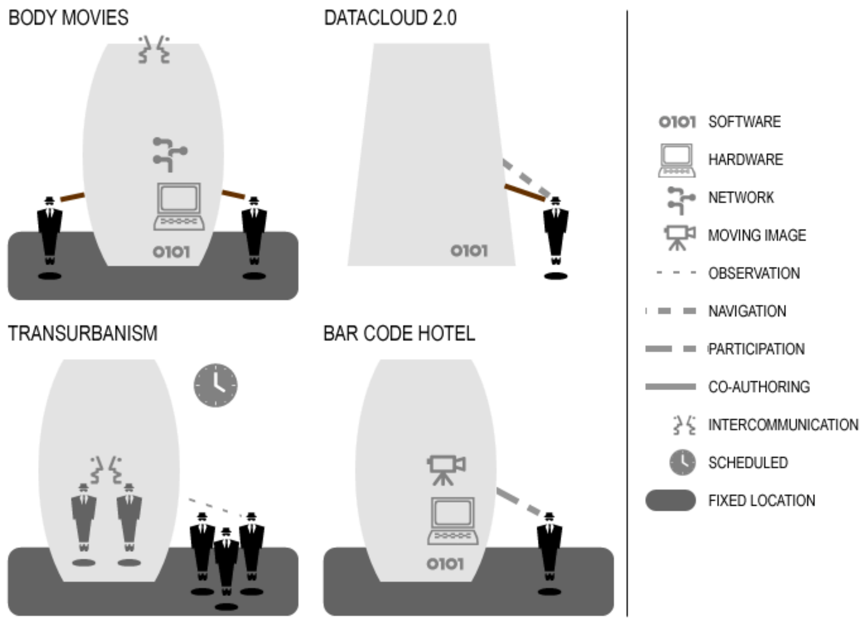

Figure 13: Schematic representations of types of interaction in Capturing Unstable Media's interaction model (Deliverable 1.3 2003, 20)

Kwastek (2013, 119) noted that the authors of the Capturing Unstable Media project had made attempts to record the instrumental aspects of interactive art. Closer examination of the Capturing Unstable Media project (Deliverable 1.3 2003) proved interesting, as it revealed a proposal for an interaction model (Figure 13) that bears some resemblance to the model of interactivity proposed in this thesis. The model contained the following parameters, each of which "were chosen for their universal nature—they are applicable to and meaningful for many modes of interaction—and because they can be defined rather objectively": time flexibility or interaction synchronicity; interaction location; number of users; level of interaction; and sensory mode.

The time flexibility parameter refers to when the interaction is to occur and whether it is scheduled or unscheduled. The interaction location refers where the interaction is to occur and whether it takes place in a specific or undefined location. The number of users refers to the types of user groupings necessary for the interaction (this was divided into single, group, and audience). The model also includes two additional separate parameters named 'minimum number of users' and 'maximum number of users'. The interaction level refers to the intensity of the interaction. Suggested values for the interaction level parameter include observational, navigational, participatory, co-authoring, and intercommunication. Finally, the sensory mode parameter refers to the user's senses that are activated during the interaction. The possible values suggested are visual, auditive, olfactory, tactile, and gustatory. (Deliverable 1.3 2003, 19)

The authors of the project acknowledged that although their model allowed for the description of "essential characteristics of user interaction", many other aspects are not amenable to formal description (Deliverable 1.3 2003, 20). They also noted that there were a number of issues with the interaction model:

» Some parameters were missing from the interaction model. Some of the parameters proposed for future inclusion included the input and output of the interaction, and the direction of the communication;
» The interaction model should be revised to include "more complex mechanisms … that can be applied to a wide variety of works". This supports the decision to produce a more expansive rather than restricted model of interactivity;
» A single work/experience/project can yield many interaction possibilities—"It is impossible to track down and describe all these possible uses of an occurrence; this would make the description of various interaction models a very complicated task." The model of interactivity is intended to enable the recording of (a) the intended/desired interaction; and (b) multiple users' interactions of the same work/experience/project for comparison.

The Capturing Unstable Media interaction model was taken into consideration when developing the final model of interactivity. The location, number of users, and sensory mode parameters were all used in the final model of interactivity. The sensory mode parameter was used in the final model following the literature review research that suggested a relationship between the senses, thought, movement, and emotion. The location and number of users parameters in the Capturing Unstable Media model partly influenced the inclusion of the spatial and social interactivity dimensions in the final model. The time flexibility parameter was also considered, but as it was not seen as a dimension of interactivity it was not included in the final model.

03

METHODOLOGY

Methodology

Description of methodology

As mentioned previously, there are two aims in this research: (1) to develop a working definition of interactivity aesthetics that can be used across a broad range of disciplines; and (2) to translate this definition into a means of evaluating the interactivity in any given learning experience. The methodology used to achieve the first aim is fairly conventional—a literature review was first conducted, after which the information from this was discussed and analysed to develop a working definition of interactivity aesthetics.

To achieve the second aim, Zimmerman, Forlizzi, and Evenson's (2007) research through design methodology was used. They described their research through design methodology thus:

> Through an active process of ideating, iterating, and critiquing potential solutions, design researchers continually reframe the problem as they attempt to make the right thing. The final output of this activity is a concrete problem framing and articulation of the preferred state, and a series of artifacts—models, prototypes, products, and documentation of the design process. (497)

Zimmerman, Forlizzi, and Evenson (2007) acknowledged that the research through design methodology involves design thinking, which they saw as "the application of a design process that involves grounding—investigation to gain multiple perspectives on a problem; ideation—generation of many possible different solutions; iteration—cyclical process of refining concept with increasing fidelity; and reflection" (494).

In practice, design thinking plays a significant role in the research through design methodology used here, particularly in the early part of the process. Overall, the main stages in this research mirror the process outlined by Zimmerman, Forlizzi, and Evenson. A literature review of existing research was first conducted across a broad range of relevant disciplines (see Chapter 2). These multiple perspectives were necessary to gain an overview of the existing interpretations and contexts of interactivity, as well as the relationships between aesthetics, interactivity, learning, and emotion. The insights from the literature review were used to inform both the working definition of interactivity aesthetics and the model of interactivity. Following the literature review, a working definition of interactivity aesthetics was produced (see page 186). This definition was used to inform the development of the model of interactivity. The key influences and insights from the literature review that were used to develop the model were presented along with the functions of the model (see page 193).

Ideation, iteration, and critique primarily occurred in Chapter 5. The ideation produced five distinct versions of the model. Each version was produced using an iterative design process (see page 167 for a description of the iterative design process). The initial models of each version were sketched and converted into digital illustration prototypes for testing (see "Ideation, testing, and evaluation" on page 220). Nine different scenarios were used for the testing of the models. The selection of these nine scenarios is explained on page 170. The tests were conducted by the researcher, who critiqued and evaluated each version of the model following the tests for that version. A multi-faceted approach to aesthetics was used to do this (see page 169 for an explanation of this approach).

After the final model of interactivity was presented, an additional critique was done by testing the final model of three Learning Experience Scenarios (see page 286). The selection of the three Learning Experience Scenarios is explained on page 176.

The iterative design process

The iterative design process is frequently used in the design of user interfaces, and involves the "steady refinement of [a] design based on user testing and other evaluation methods" (Nielsen 1993). The iterative design process used in this research is rapid prototyping, a method often used in software engineering. Rapid prototyping is a version of the iterative design process where the iterations (or prototypes) are produced in rapid succession, hence its name. It is typically used to test early versions in order to quickly assess their workability. Lantz (quoted in Tripp and Bichelmeyer 1990, 35) described rapid prototyping as a "system development methodology based on building and using a model of a system for designing, implementing, testing and installing the system".

Figure 14 depicts the stages (A, B, C, D, E, F) of the iterative design process used. Each significantly different version of the model was developed in the Ideate stage (A) as a rough

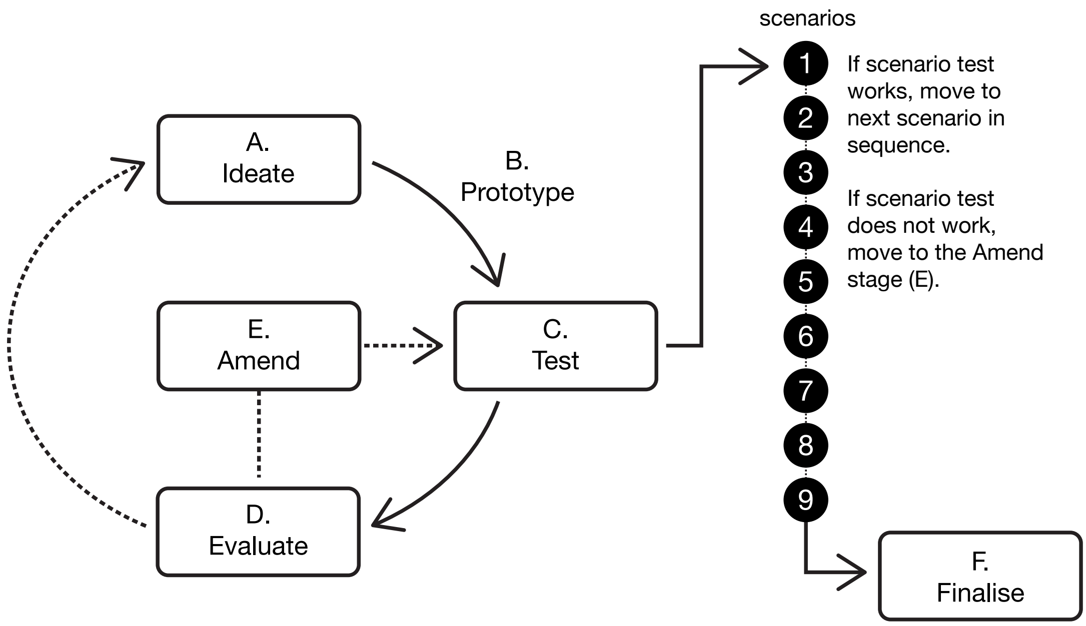

Figure 14: The iterative design process used in the Develop stage of Figure 7

pen-and-paper sketch, and then converted to a high quality digital illustration in Adobe Illustrator to be used as a prototype for testing in the Prototype stage (B). Only the high quality digital illustration prototypes have been included in this research. Each prototype was tested on between one and nine scenarios in the Test stage (C).

If a version worked with Scenario 1, it was then tested with the next scenario in the sequence, and the next, until it was unable to work. If a particular version did not work, the testing was discontinued and the process then moved to the Evaluate stage (D). In the Evaluate stage, the results of the Test stage were evaluated to identify the issues with that version of the model. After the Evaluate stage, the process moved to either the Amend stage (E) or back to the Ideate stage (A). If the process moved to the Amend stage (E), the version was adjusted to address the issues identified in the Evaluate stage (D) and then moved back to the Test stage (C) to be tested again on Scenarios 1 to 9. If the process moved to the Ideate stage (A), a significantly different version was developed using the knowledge gained from earlier versions, and the process continued accordingly. This cyclical process was repeated until a version of the model could be successfully used with all nine scenarios. When this happened, the process entered the Finalise stage (F), and the final version of the model was created.

The nine scenarios used in the Test stage (C) are described from page 170 onwards. The first scenario was tested with Version 1 of the model. This highlighted key issues with Version 1, which were addressed in Version 2. Version 2 was tested with Scenarios 1–4. Again, this highlighted issues with Version 2, and resulted in Version 3. Version 3 was then tested with all nine scenarios. The format of Version 3 was adjusted to produce Version 4, which was also tested with all nine scenarios. Version 4 was also adjusted to produce Version 5, and this was again tested with all nine scenarios.

The multi-faceted approach to aesthetics

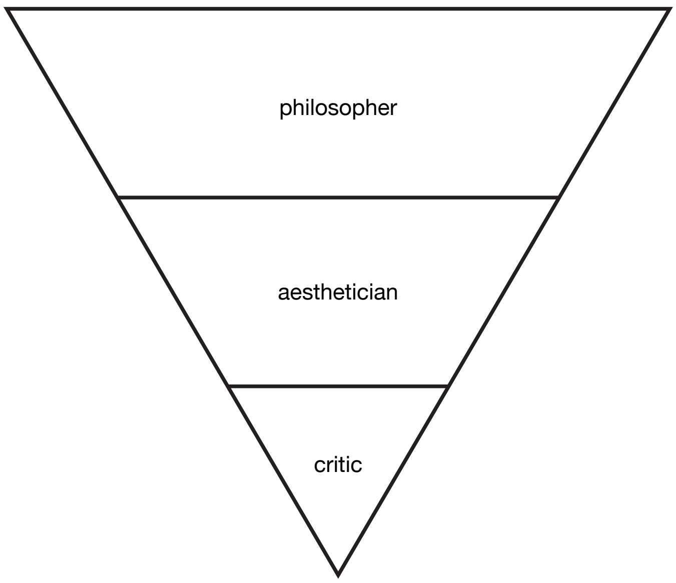

Figure 15: The philosopher, aesthetician, and critic's approach to aesthetics

The multi-faceted approach to aesthetics used here is derived from *Aesthetics from Classical Greece to the Present: A Short History* by Monroe Beardsley (1975). In it, Beardsley differentiated between three approaches to aesthetics: the critic's, the aesthetician's, and the philosopher's. Each occupies a distinct level—the philosopher at the top, the critic at the bottom, and the aesthetician in-between—and their position is determined by how broadly they view aesthetics (see Figure 15).

Critics are highly specific, applying their knowledge of aesthetics to the analysis of a given work. In Beardsley's words, they "do not invite theoretical reflection, but demand factual information and interpretative skill" (13). Zoom out a little, and you have the aestheticians' view. They engage in theoretical reflection, investigating the "theory and explanation, analysis and induction" (13-14) of aesthetics. The philosophers have a bird's eye view, in a manner of speaking. They consider "the questions about criticism itself, about the terms it uses, its methods of investigation and argument, its underlying assumptions" (14).

The multi-faceted approach to aesthetics is used in this thesis as follows:

» The critic's approach is used in the Test stage (C) of the iterative design process shown in Figure 14, where the different versions of the model are tested on the different scenarios.
» The aesthetician's approach is used to construct the working definition of interactivity aesthetics and to identify the key insights from the literature review.
» The philosopher's approach is used in the development of the working definition of interactivity aesthetics and the model of interactivity (including determining its structure and the dimensions of interactivity contained within). The philosopher's approach is also used in the Evaluate stage (D) of the iterative design process to review any issues and to make refinements where applicable. The iterative design process involves repeatedly switching between the philosopher's and the critic's approach.

Selection of scenarios

This section provides an overview of the scenarios selected for the Test stage (C) of the iterative design process and the Learning Experience Scenarios selected.

Scenarios used for testing the models

As mentioned previously, nine scenarios were selected for the Test stage (C) of the iterative design process. The selection of the experiences for the scenarios was limited to those that I, the researcher, had access to. This was not seen as a significant issue since the collective range of, and differences between, the scenarios chosen were more important than the specific individual scenarios themselves. In other words, the most important factor was that the nine scenarios should collectively contain a variety of different experiences, including at least one experience that:

» Relates to each of the five basic senses (i.e. visual, auditory, olfactory, gustatory, and somatic);
» Relates to each of the three types of mental activity (i.e. cognitive, creative, and imaginative);
» Relates to each of the two types of motor skills (i.e. fine-motor and gross-motor);
» Relates to each of the different media types (i.e. existing digital media, new digital media, and traditional non-digital media);
» Relates to non-mediated experiences;
» Occurs in real world spaces;
» Occurs in virtual spaces; and
» Relates to different types of social interactions (i.e. one-to-one, one-to-many, many-to-many) as well as individual experiences (i.e. no social interaction).

A grid was set up displaying all the criteria outlined above. The list of nine scenarios was compiled using the grid to ensure all the criteria were met. Different scenarios were tried and these were changed until all the criteria in the grid were met. The final grid is shown in Figure 16. The related scenario numbers are listed in under each criterion.

sensory	visual	auditory	olfactory	gustatory	somatic
	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 3, 4, 5, 6, 7	1, 2	1, 2	1, 2, 3, 4, 5, 6, 7, 8, 9
mental	cognitive	creative	imaginative		
	1, 2, 3, 4, 5, 7, 8, 9	3, 8	2, 6, 8		
motor	fine motor	gross motor			
	1, 2, 4, 7, 8, 9	3, 5, 6, 7, 8			
media	none	non-digital	digital (older)	digital (new)	
	1, 3, 6	2, 7	4, 8, 9	5	
spatial	real space	virtual space			
	1, 2, 3, 4, 5, 7, 8, 9	4, 5, 6, 8, 9			
social	none	1-to-1	1-to-many	many-to-many	
	2, 5, 6, 7, 8	4	9	1, 3	

Figure 16: Correlation of nine scenarios with the criteria for scenario selection

The final nine scenarios are:

1. Eating a meal with family in real life
2. Silent reading of the printed book *The Hundred-Foot Journey*
3. Playing 3-on-3 basketball in real life
4. Playing 3-on-3 basketball in the *Wii Sports Resort* game
5. Playing the *Driveclub VR* game using the Playstation VR and Playstation 4
6. Driving in a dream
7. Playing Beethoven's *Für Elise* on the piano while referring to printed sheet music
8. Painting using Photoshop on a Macbook Air
9. Texting with friends via an iPhone

The range of scenarios listed above was intentionally chosen to reflect contemporary views of learning, in which learning is seen as the product of experiences rather than the result of effective content delivery, and is about the acquisition of important life skills (e.g. socialisation, independence, self-discipline) in addition to literacy and numeracy. Furthermore, since it is uncertain what form learning experiences will take in the future, a wide variety of scenarios must be selected in order to ensure the versatility of the model.

Two pairs of similar experiences (i.e. Scenarios 3 and 4; Scenarios 5 and 6) were included to demonstrate that changing some dimensions of the experience can cause the interactivity aesthetics of an experience to change even when the essential activity is the same; this also allows them to be compared. For example, even though both Scenarios 3 and 4 involve playing 3-on-3 basketball, the interactivity present in both experiences is different. This results in differing interactivity aesthetics.

Scenario 1: Eating a meal with family in real life

Scenario 1 is eating a meal with family in real life. Eating a meal with one's family is one experience that is arguably shared by all people, regardless of gender, race, nationality, or otherwise. For many of us, the meals shared with our family are often the source of the memories we drawn on later in life. The ability of these types of memories to persist over long periods of time, suggests that shared eating experiences can produce long-term learning, even though the learning is of an informal nature and results in the acquisition of non-academic—rather than academic—knowledge (e.g. knowledge about interpersonal relationships, social etiquette, and food). Well-known chef Anthony Bourdain, for example, wrote about "a trip together down memory lane" with his brother Chris, which involved revisiting places from their youth and eating all the foods that were inextricably tied to their memories of those places (Bourdain 2001, 30). When we examine the interactivity involved in the experience of eating a meal with family later on, it will become apparent why this is so.

Scenario 2: Silently reading the printed book The Hundred-Foot Journey

Reading is a common activity in schools (e.g. silent reading, reading comprehension) and is considered an essential skill for working life. The introduction of digital technologies such as computers, smartphones, and e-readers has changed the way we read (Liu 2005; Liu and Huang 2016; Manjoo 2013; Rosenwald 2014; Rosenwald 2015). Thus, the act of reading was selected for Scenario 2—specifically, the silent reading of the printed book *The Hundred-Foot Journey*. *The Hundred-Foot Journey* by Richard C. Morais is a novel about an Indian boy and his family, and their move from Mumbai to France, where the family set up an Indian restaurant in Lumière, across the road from a traditional French fine dining restaurant. This novel was selected for Scenario 2 because it includes many detailed descriptions of the look, smell, and taste of food.

Scenario 3: Playing 3-on-3 basketball in real life

Having examined two scenarios that primarily involve fine-motor interactivity, it seemed appropriate to introduce a scenario that involves gross-motor interactivity. Since the testing of the models is conducted from my perspective, it was necessary to use a scenario that I was familiar with. Thus, playing 3-on-3 basketball in real life was selected for Scenario 3. 3-on-3 basketball is the street adaptation of regular full-court basketball. In 3-on-3 basketball, each side has three players and is played on half a court, unlike regular basketball where each side has five players and is played on a full court. I chose the experience of playing basketball, having played it since I was in my early teens. I also chose it because it could be linked to the next scenario (see Scenario 4).

Scenario 4: Playing 3-on-3 basketball in the Wii Sports Resort game

Playing 3-on-3 basketball in the *Wii Sports Resort* game on the Nintendo Wii console was selected for Scenario 4. The Wii game console was selected because I have ready access to one, and have used it before. It was also selected because there is 3-on-3 basketball in *Wii Sports Resort* on the Nintendo Wii. The 3-on-3 basketball in *Wii Sports Resort* is limited to two players only (each player controls three in-game characters), unlike playing 3-on-3 basketball in real life where there are six players. The experience of playing 3-on-3 basketball on a digital device in a virtual environment was included to provide a point of comparison for Scenario 3.

Scenario 5: Playing the Driveclub VR game using the Playstation VR and Playstation 4

Having already covered real life, non-digital media, and two-dimensional digital media in the earlier scenarios, this example looks at virtual reality. Virtual reality typically requires the use of headsets that are meant to increase the immersive quality of a virtual experience. With the growing interest in virtual reality (Ewalt 2015; Kim 2015; Rubin 2014;) and the release of the much-anticipated Oculus Rift headset in the first quarter of 2016, it seemed important and necessary to include a relevant example of this. Thus, playing the *Driveclub VR* game using the Playstation VR and Playstation 4 was selected for Scenario 5. *Driveclub VR* was selected because I had ready access to the game on Playstation 4 and the Playstation VR system. The Playstation 4 is a video game console that is manufactured by Sony. The Playstation VR system consists of a head-mounted display with nine LEDs and the Playstation Camera, which tracks the position of the LEDs to ensure the player's real-life movement is in sync with what they see in the head-mounted display (PlayStation VR 2017).

Scenario 6: Driving in a dream

Having applied the model to a virtual reality game in Scenario 5—an experience in a virtual environment using digital media—it made sense to also apply the model to an experience in a virtual environment that does not use any media: a dream. Thus, Scenario 6 is driving in a dream. I chose to use the experience of driving in a dream, so that this scenario could be compared with Scenario 5 and thus examined for similarities and differences.

It must be explained that this test is recognised as being largely conjectural and highly subjective, since it is based on memories of past dream experiences that occurred subconsciously and thus were not controlled. However, despite the obvious flaws, this test has been included because it is seen as being of significant value, since it offers an alternative perspective from which to view interactivity. Efforts have been made to consider the various aspects of dreaming in order to improve the accuracy of the interpretation of how interactivity is present in a dream. These considerations are described in the following paragraphs.

We understand dreaming to be the work of the subconscious mind since the act of dreaming occurs during sleep[90]. Consequently, if dreaming is the work of the subconscious mind and we have no control over it, the model for Scenario 6 is predictive—it merely guesses at the interactivity that is present during a dream. However, this prediction is not arbitrary—it is

[90] Some have argued that dreaming is the work of the unconscious mind, but this thesis will not delve into this topic.

informed by research from Schwartz and Maquet (2002), Zadra, Nielsen and Donderi (1998) and Hurovitz, Dunn, Domhoff and Fiss (1999).

Schwartz and Maquet (2002) observed that the representation of sensory modalities in dreams was consistent across studies, noting that visual experiences are present in nearly all dreams, with auditory experiences occurring in about 60%, movement and tactile experiences in about 15%, and smell and taste in less than 5% (24). Zadra, Nielsen and Donderi found that it is possible to have auditory, gustatory and olfactory sensory experiences in dreams. Of the 3372 dream reports they collected, they found auditory experiences occurred in approximately 33% of them, while olfactory and gustatory experiences occurred in only approximately 1% of them. Hurovitz, Dunn, Domhoff and Fiss (1999), who studied the dreams of blind men and women, found that "those blind since birth or very early childhood had (1) no visual imagery and (2) a very high percentage of gustatory, olfactory, and tactual sensory references" (183).

Scenario 7: Playing Beethoven's Für Elise on the piano using printed sheet music

Playing music is an activity that has connections to learning (Campabello et al. 2002; Scripp 2002), neuroplasticity (Pantev et al. 2003) and motor development (Wright 2017). Because of this, playing on the piano was included as Scenario 7. It was also selected because it contains a different combination of sensory, mental, motor, and media interactivity than the earlier scenarios. The quintessential classic, Beethoven's *Für Elise*, was selected because it is widely recognised and also because it is a piece I am familiar with.

Scenario 8: Painting in Adobe Photoshop on a Macbook Air

None of the previous seven scenarios involve any kind of creative production, where mental effort is expended in order to produce some form of creative output. Thus, painting was selected for Scenario 8 because it is a creative activity. However, since none of the previous scenarios involved the use of a laptop or desktop computer, it was decided that the scenario should involve painting in Adobe Photoshop on a Macbook Air using the touchpad (no additional mouse or tablet used). Adobe Photoshop is a popular digital imaging software application that is used for photo editing as well as digital drawing and painting. The Macbook Air is a laptop computer that is a product of the technology company Apple. The 2015 version of Adobe Photoshop Creative Cloud and a 13-inch, early-2015 Macbook Air were used for this scenario.

Scenario 9: Texting with friends via an iPhone

Mobile phone texting is a dominant mode of communication for youth living in Western society today. According to the Pew Research Center, in 2011, 75% of all American teenagers used texting and sent a median of 60 text messages a day (Lenhart 2012). More recently, there has been an increase in the popularity of messaging apps such as iMessage and Whatsapp. In 2015, the Pew Research Center found that 49% of 18-29 year old Americans used mobile messaging apps (Duggan 2015). In this research, messaging apps were considered to be separate and distinct from traditional cell phone texting. However, in terms of interactivity, both these forms of texting can be said to be fairly similar in terms of the dimensions of interactivity that are present. Taking this into account, texting with friends via an iPhone using the Messages app was selected for Scenario 9, since it could be used for both traditional cell phone texting and also iMessage. The iPhone (also a product of Apple) was selected because of its popularity and also because I had ready access to an iPhone. The iPhone used in this case was an iPhone 6.

Learning Experience Scenarios

To evaluate the model of interactivity and understand how it would work in practice, the model of interactivity was used to map the interactivity present in three different Learning Experience Scenarios. The three Learning Experience Scenarios described here were selected as examples of learning experiences that are both common and current. While they reflect some of the most common learning experiences in schools today, they are not necessarily *the* most common and obviously constitute only a small fraction of all the available learning experiences.

The following factors were taken into account when selecting the Learning Experience Scenarios:
» **Educational.** The experiences selected should be used in schools for the purpose of enabling students to learn.
» **Commonness and popularity.** The experiences selected should be common or popular among a large number of students.
» **Variety.** The experiences selected should each use different media, and feature a variety of different dimensions and sub-dimensions of interactivity.

Having considered the factors outlined above, the following Learning Experience Scenarios were selected:
» Doing a printed math worksheet;
» Using the Mathletics website (http://www.mathletics.com.au) on a Macbook Air; and
» Playing *Minecraft* on an iPad and an XboxOne.

The detailed descriptions of these scenarios are included in "Using the model on the Learning Experience Scenarios" on page 286. Doing a printed math worksheet was selected because it is commonly used in primary and secondary schools, and also used in education research (Montarello and Martens 2005; Naglieri and Johnson 2000). Mathletics was selected because of its widespread use in schools[91]. According to the Mathletics website, it has "a worldwide community of more than 3.5 million students and 10,000 schools" (Mathletics 2015). Muir (2014) listed it as one of three commonly used online mathematical resources alongside Google and Khan Academy. *Minecraft* was selected because of its popularity, and also because it has been touted by researchers, educators and the media as a panacea for all manner of teaching and learning problems (Dezuanni 2015; Dezuanni, O'Mara, and Beavis 2015; Dredge 2015; Thompson 2014).

Rationale

This section explains the rationale behind the choice of a research through design methodology and an iterative design process (in the form of rapid prototyping), as well as the decision to adopt a multi-faceted approach to aesthetics.

Choice of methodology

The aims of this research are to address two key problems: (1) a definition of interactivity aesthetics that can be used across disciplines does not exist; and (2) there is no easy way of showing or evaluating the interactivity in a learning experience. So, to some extent, this research can be seen as an exercise in problem-solving. One problem-solving approach considered as a research methodology was the scientific method. The contemporary scientific method is described by Cherry (1999, 37) as having the following steps:

» Pose a question (e.g. why does x happen?);
» Collect relevant evidence;
» Form a hypothesis;
» Deduce possible outcomes of the hypothesis (i.e. if the hypothesis is true, then x should happen);
» Test to determine the validity of the deduction; and
» Accept, reject, or modify the hypothesis based on the outcome of the testing stage.

[91] To use the Mathletics website, it is necessary to have a subscription, either as a family or as a school. For the purposes of this research, I took out a one-year family subscription.

The scientific method is popular and useful because it allows the verification of hypotheses through the replication of tests (or experiments) by different researchers, and at the same time facilitates the identification and control of variables that can distort results. (Cherry 1999, 37) However, the scientific method is not particularly suitable here because the problems in this instance do not necessitate identifying and proving the validity of a hypothesis –they require the creation of a solution that does not yet exist. Additionally, these problems and their solutions are complex—they can be prone to subjectivity, affected by a lack of information, fraught with uncertainty, and are likely to warrant the integration of knowledge of different disciplines. The nature of the problems in this research led to the conclusion that a research through design methodology was the most suitable.

This is due to several factors. First of all, design problems are typically complex, like the two key problems outlined above. Also, as Tripp and Bichelmeyer explained, "complex problems are subjective"—this means that every problem can have an infinite number of solutions, rather than one single ideal solution. Thus, they wrote, "The design process is endless, with no infallibly correct methodology." (1990, 34) Secondly, Zimmerman, Forlizzi, and Evenson (2007) stated that the research through design methodology is well-suited to the solving of wicked problems. Such problems are typically complex, and often occur in the absence of complete—and sometimes even adequate—information, as is the case here. This means that uncertainty is expected and must be tolerated. As Tripp and Bichelmeyer wrote:

> Decision making [sic] without adequate information is typical of design. Indeed, Schön (1988) has argued that defining characteristics of design activities are uncertainty, uniqueness, and conflict. In this light, design becomes a process of reflection-in-action; and designers take on the task of turning indeterminate situations into determinate ones (Schön, 1987). (Tripp and Bichelmeyer 1990, 34)

Lastly, Buchanan (1992) observed that design thinking is of value because it defies categorisation, and is therefore ideally situated to function as an "integrative discipline" (6). As an integrative discipline, he explained, design thinking should seek to "connect and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problems and purposes of the present" (6). This view underlies this research as well.

The iterative design process

Tripp and Bichelmeyer (1990) proposed that using rapid prototyping in instructional design (instead of the traditional systems approach) would be more efficient and just as effective. The efficiency of using rapid prototyping was the main reason it was used in this research because it allowed changes to be made easily and quickly.

The multi-faceted approach to aesthetics

Since the two aims of this research relate to interactivity aesthetics, an understanding of the philosophy of aesthetics was considered necessary, in terms of informing the functionality and construction of the model of interactivity. Thus, a multi-faceted approach to aesthetics was adopted to complement the design thinking methodology, because the parallels between the philosophy of aesthetics and the design methodology would enable them to work together synergistically. The philosopher's approach to aesthetics (see page 169) is akin to the problem-solving approach that designers use; both question the status quo and try to ascertain what is working and what is not. The aesthetician's approach resembles the way designers tackle design briefs; both involve the establishment of criteria so they can be used to assess the quality of an outcome. The critic's approach is similar to the way designers assess if a design is working (this includes testing the design and comparing it to the requirements of the brief); both involve assessing an outcome's quality or value using pre-determined criteria.

Testing of the model by the researcher

One of the limitations of this research is obviously that the testing of the model was solely conducted by the researcher. However, Schön's (1983) notion of reflective practice suggests that this is valid; after all, the researcher engaged in ongoing reflection, through the critique and evaluation of each version of the model. Furthermore, the researcher intended to build on this research by conducting future research on learning design practitioners' and learners' use of the final model of interactivity.

"Text adventure games (often referred to as 'interactive fiction' by modern scholars) used text to create the virtual environment the player inhabited. The game program provided you with a simple written description of your surroundings, then asked what you wanted to do next. … initially the text-only interface had seemed incredibly simple and crude to me. But after playing for a few minutes, I quickly became immersed in the reality created by the words on the screen. Somehow, the game's simple two-sentence room descriptions were able to conjure up vivid images in my mind's eye."

(Cline 2011, 226)

04

DEFINING THE MODEL

As described in the Methodology chapter, this chapter serves to more closely identify what the features and parts of the new model of interactivity should be. “Defining interactivity aesthetics” presents a discussion on the definition of the term ‘interactivity aesthetics’ as the understanding of this term is critical to the new model. “Key influences and insights” distills all the divergent lines of thought from the literature review to identify the key influences and insights, and establish what is required of the new model, both functionally and structurally. Finally, “Functions of the model” outlines the functional requirements of the new model.

Defining interactivity aesthetics

Before defining interactivity aesthetics, it is important to first discuss what the term 'interactivity aesthetics' refers to, why we need it, and why the term 'interactivity aesthetics' has been used instead of 'interaction aesthetics'.

What does interactivity aesthetics refer to?

It is proposed that interactivity can possess aesthetic qualities and aesthetic value. Admittedly, the concept of interactivity aesthetics has not been recognised or clearly defined as yet, but this does not mean that it does not exist. Sam Jordison's review of Egmont's Classic Winnie-the-Pooh iPad app[92] illustrates what interactivity aesthetics is—it shows how the aesthetics of an experience can be altered by changing the interactivity involved. Jordison described how the addition of what he called "interactivity" to images negatively affected his daughter's experience of reading a Winnie-the-Pooh book:

> The animations (which you press to set running) get in the way of the words. The words get in the way of finding and pressing the next animation. It wasn't quite a book, it wasn't quite a cartoon, it wasn't quite a game. But it was quite boring.
>
> Admittedly, I'm not the target audience. I am not—alas—one of today's children. But my five-year-old daughter is—so I gave her the app to see what she made of it. At first she looked very pleased. She listened to the story, she enjoyed the EH Shepard pictures, which are, after all, beautiful. But as soon as she worked out that you could make the pictures move she became distracted. Then she became annoyed that she couldn't make the animations do more. Then she started to express frustration that she had to push through the text to get to the next pictures. Then she started skipping. Then she lost track of the story. Then, within five minutes of first opening

[92] The app can be downloaded at https://itunes.apple.com/au/app/classic-winnie-the-pooh/id647809786?mt=8.

> the app, she got to the end.
>
> "You can delete it now Daddy," she said.
>
> "Don't you want to look at it again?"
>
> "No."
>
> So much for the digital revolution. (Jordison 2013)

After downloading and examining the same iPad app Jordison used, it was observed that although visual aesthetics of the app and the printed version of the book were similar—they both had the same text and illustrations—the interactivity aesthetics were different because the images in the app were interactive, but those in the book were not. This changed the aesthetic experience of the narrative content. Hence, one can no longer take aesthetics to refer only to visual aesthetics. Interactive technologies have changed this paradigm because the interactivity they supply has added new functions to visuals and text. Accordingly, in order to be able to discuss interactivity aesthetics it is necessary to develop a proper definition of it.

Why do we need interactivity aesthetics?

To understand why we need interactivity aesthetics, it is helpful to use concrete examples for the purposes of explanation. Here two examples are discussed. The first example relates to experiences in real-world spaces versus virtual spaces. An experience can contain a combination of both real and the virtual; it is possible move seamlessly between the real and the virtual within a single experience. Kwastek (2013, 261) explains that this refers to when aesthetic distance is "in oscillation between artificiality and reality". However, an experience arguably does not only involve oscillating between real and virtual spaces, but could also involve being simultaneously present in both. Individually, experiences involving each of these spaces has a different aesthetic quality. This very likely differs from the aesthetic quality of experiences that occur simultaneously in both virtual and real-world spaces. However, there is no proper method of describing or discussing these aesthetic differences as yet. Formally recognising interactivity aesthetics as a construct and establishing what constitutes it is one possible means of addressing this.

The second example relates to the difficulty in differentiating between the interactivity occurring in different dialogical contexts. Here the 21 Swings installation in Montréal is used to explain this. The 21 Swings installation is a set of 21 musical light-emitting swings, in which each swing in the installation produces a different coloured light and pre-recorded sound from the others, and if "swung in unison with careful cooperation, more complex melodies and harmonies arise" (Jobson 2012). It involves both human-computer interaction and human-human interaction. With regard to the former, the swings are the devices (the equivalent of computers), and they participate in a dialogue with the swing users. In relation to the latter, the swings are tools that facilitate the dialogue between different swing users. So, if interactivity is present between the user and the swing, as well as between users, how do we differentiate the interactivity between a person and a device from the interactivity between two people via a device? How do we then compare the interactivity between two people via a device with the interactivity between two people that is facilitated by the architectural design of a building? Additionally, how would also differentiate these from situations where digital technologies (or devices) are incorporated into the architectural design of a building to facilitate interactivity between people?

The 21 Swings installation demonstrates the limitation of the human-computer perspective of interactivity—that it is too generalised to be used for differentiating between the dimensions of interactivity arising from the rapid advances made in technology. The human-human and media perspectives, viewed in isolation, are also similarly restrictive. At the same time, the human-computer perspective of interactivity also fails to adequately reflect the changes that are occurring in contemporary interpretations of experience, especially in relation to aesthetic experience and experience design. Here, too, interactivity aesthetics can be of use.

Why 'interactivity aesthetics' instead of 'interaction aesthetics' or 'aesthetics of interaction'?

The term 'aesthetics of interaction' has been used for some time in interaction design, however its use has largely been limited to HCI and interaction design and does not include interactions that do not involve the use of computers or other forms of technology. This is different from the proposed use of the term 'interactivity aesthetics'. In this context, interactivity is understood as the invisible or unseen activity that occurs during the visible activity or action performed during an interaction. The decision to articulate and focus on the invisible activity in this research addresses a gap in perception that is—somewhat ironically—the result of our human tendency to pay attention to what we can see and ignore what we cannot. It seeks to level the playing field, as it were, for the other senses that are often all but forgotten, but which play an equally important role in the way we perceive and interpret sensory information from the world around us. It also takes a broader view of interaction, one that views non-human-computer interaction (including real-life interaction that does not involve any media or technology use) on the same plane as human-computer interaction. This builds on the holistic approach already used in HCI and extends it further to expand our understanding of human perception and learning across all aspects of everyday life, not just those that involve the use of technology.

The use of 'interactivity' in the term 'interactivity aesthetics' is important because highlights the universality of interactivity in all experiences, not just digital-based ones. As Lopes (2001, 67) declared, "After all, what activity is not interactive? Playing a hyperinstrument is interactive in just the way playing a violin or piano is interactive." As such, the definition of interactivity presented here does not focus on interactivity's ability to give users co-authorship or facilitate immersion, or debate whether interactivity is about behaviour or is a characteristic of technology. Instead, the interpretation of interactivity here is broader than conventional interpretations (e.g. Neuberger and the Capturing Unstable Media Project) and includes not only the interactions between humans and technology, but also real life interactions between humans and everything around them. This view of interactivity is not a novel one, and can be said to align closely with that of Sohn (2011). More importantly, understanding interactivity in this manner not only reflects the transmutable nature of experience; by virtue of its universality, it could also be used to examine the interactivity in any given experience.

A definition of interactivity aesthetics

It is important to mention that the definition of interactivity aesthetics presented here is simply *a* definition, and more of a working definition rather than a final, definitive one. This definition is derived from the definitions of interactivity and aesthetic experience provided here. The key influences of the definitions are first discussed, after which the definitions of interactivity and aesthetic experience are each presented separately. These are then followed by the proposed definition of interactivity aesthetics.

Key influences

Stecker and Gracyk's (2010) proposition that all experiences be considered aesthetic experiences has been adopted in this research, in the tradition of others such as McCarthy and Wright (2004). Additionally, this thesis also takes into account the views of both Kwastek (2013) and Lopes (2001). Kwastek's view was used to inform the internalist theories of aesthetic experience presented in this research, in which personal aesthetic experience is considered to be paramount to understanding and interpreting interactivity. Lopes' view, on the other hand, was used to inform the externalist theories of aesthetic experience, since he focused more on the work being experienced (e.g. its structure[93]) than on a user's personal experience of the work. Both views are seen as equally important. Thus, this research considers internalist theories and externalist theories in conjunction with each other since their relationship is viewed as complementary, not contradictory.

Proposed definition of interactivity

A broader interpretation of interactivity is used here which views interactivity as *the state of doing*[94] (or that which is present during an interaction). Interaction, on the other hand, refers to *the act of doing*. In other words, it is proposed that interactivity is that which is present during all the activity, both internal and external, that occurs simultaneously during an experience. This view partially relates to Jensen's (2013) definition of experience. According to Jensen, an experience is produced by the sensory-based effects that result from interactions and is influenced by the internal state of the individual having the experience, as well as the external factors related to the experience.

More precisely, interactivity refers to that which occurs during an interaction, where a person interacts with another person, an object, a location, or information (e.g. written text, mathematical calculations, etc.). Interactivity is the state one is in during an interaction, rather than the interaction itself—it is present during an interaction, but is not the interaction itself. Thus, interactivity is present in all experiences, whether the experience is mediated or non-mediated, real or virtual. Interactivity is made up of different dimensions, and during an experience one or more of these interactivity dimensions are present. Interactivity includes both intended interactivity (by the designer/creator, if applicable) and perceived interactivity

[93] Lopes (2001) and Ryan (2001) both wrote about strong and weak interactivity. However, Lopes focused more on the structural properties in relation to interactivity, whereas Ryan was more concerned with the role of the reader (or person engaged in the narrative). Lopes described weak interactivity as "those that give users control over the sequence in which they may access content" and strong interactivity as those where "the structure itself is shaped in part by the interactor's choices" (Lopes 2001, 68).

[94] This is a play on the phrase 'a state of being'. The active nature of interactivity warrants a change from 'being' (which suggests mere existence) to 'doing'.

(by the user/viewer/experience; see also page 72). This is similar to Gibson's concept of affordances (see page 58) in that it takes into account the relationship between the user and her environment, but goes beyond it in that it includes her emotions as well. Lastly, interactivity is seen as necessary for learning. It enables us to acquire information during interactions, and learning occurs when we retain the information we acquire and use it to change our future behaviours.

It is believed that this interpretation of interactivity is expansive enough to accommodate most—and hopefully all—interactivity dimensions found across all experiences, and also allow it to be applied to both the potential as well as the actual processes that occur during an experience. This definition of interactivity was produced with the intent to keep it as universal as possible –this was seen as a necessity after examining the numerous and varied interpretations of interactivity[95]. It must be emphasised that the definition proposed here is not a definitive one. Rather, it is intended to function as a working definition, and attempts to contribute in some way toward the eventual development of a universally accepted definition.

A different concept of aesthetic experience

McCarthy and Wright's (2004) description of ordinary experience as "everyday raw aesthetic experiences that demand our attention and make us come alive" (58) suggests that their view of aesthetic experience does not apply to all experiences, but is limited to experiences that provide sensory pleasure, excite the mind, or provoke a positive emotional response. This view appears to come from their interpretation of Dewey, whom they quoted as stating that "the humdrum; slackness of loose ends; submission to convention in practice and intellectual procedure" was opposed to the aesthetic (58). However, this arguably seems to contradict their claim that aesthetic experience "should be seen as continuous with ordinary experience" (57).

Aesthetic experience cannot be seen as continuous with ordinary experience if one is selective about the kinds of ordinary experience that is taken into account. Here it is the use of the word 'aesthetic' that is problematic. This is not surprising. Given its history, the word 'aesthetic' is a loaded term. McCarthy and Wright (2004), for example, used the word 'aesthetic' to connote quality or goodness in their discussion about technology-based experiences, in which these were framed as aesthetic experiences. They also referred to Laurel's description of qualities of

[95] This was discussed in "Defining interactivity" (see page 62).

engagement that indicate “a good experience at a play or with a computer” and to Murray’s identification of “three characteristic pleasures of digital environments: immersion, agency, and transformation” (61). Overall, McCarthy and Wright’s perspective reflects the general view that ‘aesthetic’ indicates quality or goodness, and that the opposite is true of that which is not ‘aesthetic’.

This view contradicts the more contemporary view of aesthetic experience and experience put forward by Stecker and Gracyk (2010), who declared that all experiences are aesthetic experiences. Furthermore, by using the term ‘aesthetic’ as an indicator of quality or goodness, McCarthy and Wright focus on the dichotomy of goodness and badness at the expense of the other aspects of Dewey’s aesthetic experience, in particular the notions that aesthetic experience “involves a drama in which action, feeling, and meaning are one” and consists of a series of synchronised and connected events (Leddy 2016). These notions suggest that although Dewey saw aesthetic experience as being defined by the presence of feeling (or emotion), he did not discriminate between good or bad feelings. Rather, his view of aesthetic experience can be interpreted as being more concerned with whether feeling was present in conjunction with action and meaning, and with whether the events (or actions) involved were connected or not. After all, Dewey referred to the opposite—a series of unsynchronised and disconnected events (or actions)—as non-aesthetic experiences and did not consider them to constitute either an experience or an aesthetic experience (Leddy 2016).

Thus, it is the latter, more contemporary view, that has been adopted here. This is because to subscribe to the former would result in the exclusion of a significant segment of learning experiences simply because they lacked aesthetic value. This also takes into account Dewey’s view that philosophical and scientific experiences can possess aesthetic qualities, and Stecker and Gracyk’s (2010, 34) suggestion that aesthetic experience may not be limited to nature and art, and may instead be found in “the everyday, math, and science”. However, although this thesis supports the Deweyan notion that aesthetic experience “involves a drama in which action, feeling, and meaning are one” (Leddy 2016), it is proposed here that movement, emotion, and thought do not all have to be present for an experience to be considered an aesthetic experience. Viewing a painting, for example, would be considered an aesthetic experience, even though the act of viewing does not involve any motor movement (unless one includes the movement of the eyeballs).

The broader, more inclusive concept of aesthetic experience adopted here is also partly influenced by Kant[96]. First, aesthetic experiences are viewed as being characterised by Kant's concept of universality. This is not to say that exceptions or slight variations between individuals do not occur, but rather that aesthetic experiences are universal because to some extent we believe that others perceive them the same way we do. In other words, we assume everyone else sees the sky as being blue in colour because that is how it appears to us, even though the actual shade of blue perceived may vary from person to person. Second, the Kantian notion of disinterest is also inherent in aesthetic experiences. After all, there are times where we are engaged in an experience, but are not conscious of it being an experience, or are not consciously aware of the aesthetic qualities present in the experience; we are too focused on what is happening during the experience. Finally, like Kant, this thesis proposes that aesthetic judgements should not be bound by rules—in particular, those that limit aesthetics to the realms of art and nature.

However, the concepts of aesthetics and aesthetic experience adopted here also differ from Kant's in some respects. First, Kant argued that which is aesthetic should be able to engage the senses, imagination and intellect. Here it is argued that this is not only applicable to art—all experiences do this, though some do so better than others, and the degree to which the senses, imagination, and intellect are engaged differ from one experience to another. Second, contrary to what Kant proposed, it is understood here that aesthetics does not have to be derived from pleasure, or that experiences must be pleasurable in order to be considered aesthetic experiences. (However, this does not mean that pleasure cannot be present.) Instead, aesthetics is seen as the assemblage of the neutral qualities of an experience (e.g. visually interactive and socially interactive, as opposed to good or bad)—not as something to be judged, or a means by which the aesthetic value of something is judged. Accordingly, then, since aesthetics is not characterised by the presence of beauty, but by the presence of aesthetic qualities (i.e. visually interactive, as mentioned), an experience does not have to be beautiful to be an aesthetic experience, but it must have aesthetic qualities. This relates back to Stecker and Gracyk's view that all human experiences—real or digital, artistic or scientific, sensory or cognitive—are aesthetic experiences, since they all have aesthetic qualities.

Consequently, if all experiences—whether art or nature-based, philosophical or scientific—are aesthetic experiences, the term 'aesthetic experience' is superfluous. Yet even if the term 'aesthetic experience' is seen as redundant, the term 'aesthetics' continues to have value here.

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[96] This might seem rather ironic and contradictory, given that the aforementioned analytic philosophers used Kant's views to oppose Dewey's pragmatism. See "Analytic philosophy and pragmatism" on page 29.

This value is derived from its usefulness as a descriptor of the characteristics of an experience. Specifically, this means that 'aesthetics' refers to the characteristics that result in the 'look and feel' of an experience, not whether an experience is bad or good, beautiful or ugly. Wellman (2008, 250) defined 'look and feel' as "the impression that the object makes on the viewer, the effect it produces, the character it seems to possess, or the expression that its exterior forms." Jansen (2013), a designer from web design firm Bop Design, defined it similarly, "In its most basic terms, the "look and feel" of a website is how the site looks to the user and how it feels when he or she is interacting with it." Jansen also stated that colours, images, layout, fonts, and overall style influence the 'look', while "[the] movement and response of dynamic components like dropdown menus, buttons, forms, and galleries", sound, and "[the] speed by which pages and images load" contribute to the 'feel'. Therefore, one can take the 'look' to generally refer to the visual aesthetics, while the 'feel' is typically understood to refer to the non-visual aesthetics (in other words, the aesthetics relating to other sensory modes that are more difficult to articulate), as well as feelings evoked by the visual and non-visual aesthetics. Thus, the interactivity aesthetics of an experience can be said to be the 'feel' of that experience.

The definition of interactivity aesthetics

As mentioned previously, the interactivity aesthetics of an experience can be said to be the 'feel' of that experience. More specifically, the term 'interactivity aesthetics' is used to refer collectively to the different characteristics or qualities that combine to produce a felt experience. This is regardless of whether they possess a high aesthetic value; it is not a descriptor of the aesthetic quality of that experience. The assumption is that different dimensions of interactivity combine to form an experience, and that different combinations and configurations of these dimensions of interactivity are likely to produce different interactivity aesthetics. Figure 17 and Figure 18 illustrate how this might be so[97]. Figure 17 shows a particular individual (James) talking to a friend (Sarah) in real life while using an iPad app and watching TV, while Figure 18 shows James listening to music while using the same iPad app. Although James is using the same iPad app in both scenarios, one can expect that the interactivity aesthetics of both experiences of the iPad app would be different.

[97] Both of these were based off Jensen's (2013) model in Figure 1.

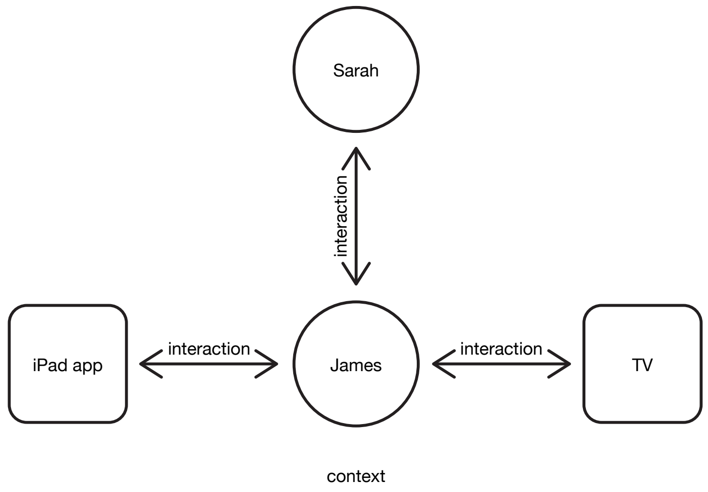

Figure 17: Using an iPad app while watching TV with a friend

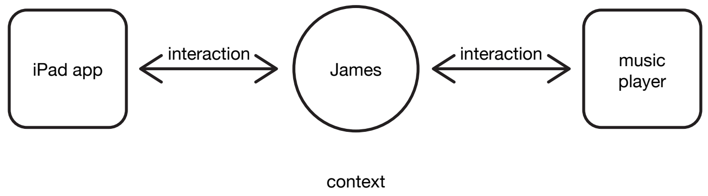

Figure 18: Using an iPad app while listening to music alone

Key influences and insights

In this section, "Key influences" first outlines the key influences from the literature review that led to particular outcomes in the model of interactivity. Subsequently, in "Key insights" examines the key insights distilled from the literature review. These insights are categorised under the following three main headings:

» Aesthetics, experience, and interactivity
» Technology, experience, and interactivity
» Emotion, aesthetics, learning, and interactivity

Each of these headings reflects the different topics that have been clustered for discussion.

Key influences

The pragmatist philosopher John Dewey[98] was a key influence in the development of the model of interactivity, particular his views on experience. He saw experience as a process that involves us interacting with our surroundings, during which we first acquire sensory information and then interpret it. He also recognised that all experiences, whether they were artistic or ordinary, could be aesthetic. Thus, the model of interactivity was developed with the view that it should be able to reflect both the acquistion and interpretation of information during an experience, as well as be able to work with any and all types of experiences.

[98] See pages 30, 31, and 32.

Another key influence was the repeated suggestions that experience consisted of the sensory, emotional, and intellectual (or cognitive). In some instances, movement was also included. For example, McCarthy and Wright (2004, 54) mentioned that "a person's full relationship … with his or her physical and social environment" encompassed the sensory, emotional, and intellectual. Two of the four threads of experience they identified were sensory and emotional. Laurel (1991, 32) wrote about the relationship between "minds, feelings, and sensations". Jensen (2013, 196-197) referred to the sensory, emotional, and knowledge. Overbeeke et al. (2002) made similar distinctions, between the cognitive, perceptual-motor (they combined sensory and motor), and emotion. Sohn (2011) proposed three dimensions of interactivity: sensory, semantic (similar to cognition, it refers to the processing of sensory information), and behavioural (this refers to the behaviour and actions that occur as a result). Damasio's (2008) work in the field of neuroscience supported these views; he noted that when we interact with our environment, the body and brain function together as a whole, not separately, and they are largely influenced by emotion. Research also suggested a relationship between movement and thought (Cotman, Berchtold and Christie 2007; Hamblin 2014; Jensen 2005; Ratey 2012) as well as between emotion and thought (Weiss 2000). From a media literacy perspective, Potter (2008) identified the cognitive, emotional, and aesthetic (i.e. sensory information) as three of the four dimensions of information. All these pointed to a need to represent emotion, movement, thought, and sensory perception within for the model of interactivity.

Alongside this, it became apparent that the inclusion of both internalist and externalist approaches would also be useful. These are taken from both philosophy relating to aesthetic experience as well as Lavazza and Manzotti's (2011) work on neuroscience and aesthetics (or neuroesthetics). From philosophy perspective, the internalist approach is influenced by internalist theories (e.g. Dewey), where the focus is on "features internal to experience", while the externalist approach is influenced by externalist theories (e.g. Beardsley) that focus on "features of the object experienced" (Shelley 2013). From Lavazza and Manzotti, the view of internalism, where "the idea that the mind is located inside the body" (508), is adopted alongside externalism, which considers "the interaction of the embodied brain and the world" (509). Consequently, it made sense to categorise the dimensions associated with the emotion, movement, thought, and sensory perception of the individual as internalist, since they occur inside the body and are aspects of experience that are internalised in the individual.

At the same time, it was also clear that there must also be externalist dimensions at play. These dimensions were necessarily found outside the individual, and the work by McCarthy and Wright (2004), Sohn (2011), Fornäs (1998), Jensen (2013), Mitchell (2015) helped to identify these. Jensen recognised that the context of experience was important, while Mitchell highlighted that both real world and virtual experiences had real world consequences and should be considered together. Sohn emphasised the social aspect of interactivity, and that interactivity should include "any interaction involving humans whether direct or mediated" (1325). This means that experiences that do not involve any media use should be considered alongside those that use non-digital media and digital media, as well as experiences that combine two or all of these. Similarly, Fornäs noted that interactivity "resides more in the relation between media and their users than in the media themselves" (31). McCarthy and Wright declared that experiences can be simultaneously individual and social. As such, it was clear that the externalist category needed to include space (real and virtual), media, and social dimensions.

The division of the dimensions into sub-dimensions was partially derived from the sources that were the key influences. The sensory sub-dimensions were taken from Damasio (2008) the basic and commonly recognised five dimensions: sight, sound, smell, taste, and touch. These same dimensions were also used in Dunn's Sensory Mapping infographic. Since the intention is to develop a model that can be widely used, it made sense to use the five basic senses as they are commonly recognised across all disciplines, whereas the recognition of more obscure senses such as proprioception would be limited to a specialist audience. The thought dimension had to include cognitive activity as a sub-dimension since it was mentioned repeatedly (e.g. Overbeeke et al. 2002; Potter 2008). However, imaginative activity was also included as a sub-dimension because Everding (2009) and Barnard's Interacting Cognitive Subsystems (ICS) framework (Barnard and Teasdale 1991) highlighted that imagination (or visual imagery) was distinct from cognition. The social dimension was divided into sub-dimensions based on the work by McCarthy and Wright (2004). McCarthy and Wright mentioned that experiences could be individual, social, or both. Sohn (2011) influenced the placement of the social dimension next to media dimension, having pointed out that social interaction could occur both through media and without media.

It is necessary to mention that the circular design of the model was developed during the ideation process prior to discovering the circular models by Dunn, Barnard, and Plutchik. However, these were included in this research to demonstrate the feasibility of the use of such a model structure.

Key insights

Aesthetics, experience, and interactivity

As a whole, the literature review highlighted the following insights in relation to aesthetics, experience, and interactivity:

- » Experience is of primary importance;
- » Aesthetics is inherent in all experiences; and
- » Experience involves interactivity.

Each of these insights is discussed and explained below.

Experience is of primary importance

It was observed that the 21st century is focused on experiences (Oppelaar et al. 2008, cited in Jensen 2013, 180). This phenomenon was explored in "Interaction, interface, and interactivity" on page 91, where Pine II and Gilmore (1998)'s notion of the Experience Economy and Hassenzahl's (2013) notion of the Experience Society were discussed. From this, it was apparent that experience has become a central focus in contemporary society. The literature review also reaffirmed the importance of experience, across multiple academic disciplines. These included philosophy, human-computer interaction, user experience design, and education. The key points relating to each of these disciplines is presented in the next paragraph.

It was discovered that experience was a key topic in pragmatist philosophy in "Philosophical theories on aesthetics" (page 28). In "Technology and aesthetics" (page 41), the relationship between pragmatist philosophy and experience was also discussed, in the context of McCarthy and Wright's (2004) proposition that technology be viewed as experience. Experience was also mentioned in Tractinsky's (2016) chapter on visual aesthetics, in response to which Bardzell discussed the importance of aesthetic experience in HCI and other interaction-based design disciplines. "Interaction, interface, and interactivity" (page 91) described how the increased interest in experience led to the emergence of new disciplines such as experience design and user experience design. "Learning and education" (page 109) explored the notions that learning itself is an experience and that we can learn from experience. In relation to the latter, learning experience design and Kolb's Experiential Learning Theory were examined. The role of emotion in experience was considered in "Emotion, learning, and aesthetics" (page 148), in particular McCarthy, Wright and Meekison's (2005) four threads of experience, of which one is the emotional thread.

From all these separate discussions, it was apparent that experience was a common recurring theme. This suggests that it may be useful to extend on McCarthy and Wright's suggestion to view technology as experience, and use experience as the common point of comparison so that aesthetics, technology, learning, emotion, and interactivity can be studied in conjunction with each other rather than individually.

Aesthetics is inherent in all experiences

Placing experience at the centre of discussion naturally makes pragmatism particularly relevant, especially contemporary approaches to pragmatism such as Stecker and Gracyk (2010). These contemporary perspectives recognise that ordinary everyday experiences can also possess aesthetic qualities and, in doing so, is changing our understanding of both aesthetics and experience. This broader interpretation of aesthetics means the role of aesthetics is more important than ever. This was shown in "The role of aesthetics" (page 23), where the examination of the historical evolution of aesthetics showed how its role in contemporary society is becoming increasingly significant. It also highlighted that, in order to leverage the benefits of this approach to aesthetics, there needs to be greater collaboration between the arts and the sciences.

At the same time, however, the view that aesthetics is inherent in ordinary everyday experiences still seemed to exclude experiences that were not meaningful or satisfying. McCarthy and Wright (2004), for instance, took aesthetic experience to encompass primarily those which involved:

> ... the lively integration of means and ends, meaning and movement, involving all our sensory and intellectual faculties is emotionally satisfying and fulfilling. Each act relates meaningfully to the total action and is felt by the experiencer to have a unity or a wholeness that is fulfilling. (58)

The issue with this is that, by emphasising the importance of emotional fulfilment and satisfaction, it automatically disregards experiences that do not produce a feeling of unity or wholeness. This is problematic not only because it exempts negative experiences (that leave the individual feeling 'unwhole') from consideration, but also because it evitably results in contradictions, whereby the same experience could alternately be seen as aesthetic or non-aesthetic based on whether it produces a feeling of wholeness in one or more individuals. After all, just because an experience is satisfying for one individual does not mean that it will be for another (or for all individuals). If this is the case, how can it be possible to determine the success of a single designed experience, since every individual will respond to it differently? Also, does it mean that we should be designing a different experience for each individual, and if we do, how feasible is it to do so?

Experience involves interactivity

The literature review showed that there is relationship between experience and interactivity. In "Interactivity in art" on page 67, it was observed that interactivity is seen as inherent in all experiences. Separately, in "Sohn's views on interactivity" on page 72, Sohn (2011) wrote about interactivity as being a subjective rather than objective phenomenon, proposing that perceived interactivity is "what constitutes a person's perceptual experience of interaction" (1321).

Technology, experience, and interactivity

The insights relating to technology, experience, and interactivity are primarily derived from the work by McCarthy and Wright on technology and experience in "Aesthetics" (page 22), and the section "Interactivity" (page 61). They are:

» Interactivity is a product of interaction, not a characteristic of technology;
» The dimensions of interactivity are different from the characteristics of interactivity;
» An experience-based perspective should be used with interactivity as a common lens; and
» Potential interactivity is distinct from perceived interactivity.

Each of these insights is discussed and explained below.

Interactivity is a product of interaction, not a characteristic of technology

The view that interactivity is a product of interaction, not a characteristic of technology, is influenced by Sohn (2011) and Biocca (2013). As pointed out in the literature review, Sohn argued that interactivity occurs during "any interaction involving humans, whether direct or mediated" (1325) and that interactivity is "a user's *perceptual experience* rather than a technological attribute" (1322, emphasis in the original). Similarly, Biocca noted:

> What is most critical to the structure of a new medium is not the silicon, plastic, fiber optics, and copper that form the technology, but the way the medium is coupled to the human mind and body. It is in this coupling of medium, body, and mind that the explanation of the fuzzy concept of interaction lies. (100)

Sohn and Biocca's approach relates to the concept of phenomenology, a discipline within philosophy that examines "structures of consciousness as experienced from the first-person point of view" (Smith 2018). Phenomenology is concerned with the first-person perspective of lived experience (rather than a third-person observation of what an experience is, which is more ontological), including how it appears to us and also how we derive meaning from it. Additionally, phenomenology recognises that this perspective is subjective because it can vary from individual to individual. (Smith 2018) This aligns with Sohn's notion of perceived interactivity, which acknowledged that the interactivity in an experience can vary with each individual. Phenomenology also has relevance in terms of the many forms of experience that are studied (including perception, thought, memory, imagination, emotion, desire, embodied action, social activity, etc.) (Smith 2018)—these forms were also mentioned in other disciplines, as can be seen in the "Key influences" section.

The notion that interactivity is a product of interaction is also supported by phenomenology's concern with consciousness as well as intentionality. At a basic level, consciousness means the individual is aware of the experience as it happens, while intentionality means that the individual frames the experience through particular concepts, thoughts, images, etc. to derive meaning from it (Smith 2018). Since the focus is primarily on interaction that is purposeful, it is natural for the individual to expect and be aware of the resulting interactivity, and to be able to derive meaning from it using their existing knowledge structures, especially in the context of learning.

In terms of eschewing the view that interactivity is solely a characteristic of technology, a focus on specific technologies is foolhardy because, as Biocca (2013) pointed out, technology is "constantly evolving" (101). Thus, for the purpose of future-proofing and also given that all experiences involve interactivity (as previously noted on page 198) not just technology-related ones, it seems sensible to adopt the view that interactivity is not solely a characteristic of technology.

The dimensions of interactivity are different from the characteristics of interactivity

The distinction between dimensions and characteristics was only identified after the development of Version 1 of the model, which necessitated additional research. The additional research (included in the DISCOVER section) reaffirmed that the dimensions and characteristics of interactivity were different. Two main approaches were evident in the discussions relating to interactivity—one approach focused on the *characteristics* of interactivity and the other focused on the *dimensions* of interactivity. The majority of the discussions focused on the characteristics (Frasca 2003; Lopes 2001; Manovich 2001; Norman 1988; Penny

2011; Ryan 2001). A smaller number of discussions (Sohn 2011; Steuer 1992) focused on the existence of different dimensions and sub-dimensions of interactivity. The characteristics of interactivity can be said to describe the nature of interactivity (i.e. what the interactivity is like). The dimensions of interactivity, on the other hand, can be seen as a means of identifying the constituent parts that worked together to produce interactivity (i.e. what interactivity is made up of).

Consequently, the characteristics of interactivity tend to be dualistic (e.g. voluntary versus compulsory) and, if viewed in isolation, can be limiting. Conversely, the dimensions of interactivity are not dualistic—they recognise that interactivity is made up of more than two dimensions. It is useful to consider both dimensions and characteristics when discussing interactivity in depth because this provides a more robust conceptualisation of interactivity. However, the limits of this research make it difficult to include the characteristics of interactivity at this point. Regardless, a summary of the characterististics of interactivity is presented here for current and future reference.

Summary of the characteristics of interactivity

This list of characteristics is by no means complete. It warrants a separate and more thorough investigation, which is beyond the scope of this thesis. Where applicable, the characteristics are listed as opposing pairs (e.g. voluntary versus compulsory) in order to make the list more comprehensive. Characteristics that have been mentioned and discussed previously by other scholars are indicated accordingly.

» **Voluntary versus compulsory:** This refers to whether the engagement with the other person/object/world is voluntary (i.e. initiated by the user) or compulsory (i.e. user is forced to engage, for example in the case of reading a book in class);

» **Intrinsically-motivated versus extrinsically-motivated:** This is slightly different from the previous. Intrinsic motivation comes from within the learner, for example, the learner wishes to improve his typing ability, and thus voluntarily engages in typing exercises. However, it is also possible for a learner to voluntarily engage in an activity that is extrinsically-motivated, such as completing a learning activity to receive a reward;

» **Intentional versus unintentional / Reflective versus reflexive:** This refers to whether the interaction is intentional (i.e. actively considered) as opposed to unintentional (i.e. a matter of reflex);

» **Repetitive versus non-repetitive:** The user engages with the other person/object/ etc. repeatedly (for example, replaying the same game, re-watching a movie, re-reading a passage, copying out alphabets), or the user engages with the other person/object/etc. once only. Something that is designed to be non-repetitive can become repetitive if the user voluntarily chooses to repeat it. Alternatively, something designed to be repetitive, but is poorly designed, may discourage users from wanting to voluntarily repeat, but in certain instances, users may be forced to repeat;

» **Predictable versus unpredictable:** This refers to the predictability of the outcome of the interaction;

» **High novelty versus low novelty:** This refers to whether the outcome of the interaction is novel (i.e. new to the user) or not. It can be linked to the interaction's predictability;

» **High variety versus low variety:** This refers to the range of different instances where the specific sub-dimension of interactivity is present (e.g. the variety of visual interactivity present when reading an illustrated book where there is a variety of text and images);

» **High risk versus low risk:** This refers to the level of risk involved in the activity. For instance, learning to do skateboard stunts in real life involves a greater risk of personal injury than doing so in a video game;

» **High control versus low control:** This refers to the amount of control users have over the interaction. One example of this is provided by Frasca (2003, 229), where he differentiates between narrauthors and simauthors: "Narrauthors have executive power: they deal with particular issues. On the other hand, simauthors behave more like legislators: they are the ones who craft laws. They do take more authorial risks than narrauthors because they give away part of their control over their work";

» **Strong interactivity versus weak interactivity:** This refers to the effect the learner (or user) has on the system. Strong interactivity means the learner has a significant effect, while weak interactivity means the learner has little or no effect. (See also Ryan 2011 and Lopes 2011);

» **Closed versus open:** In closed systems, the outcomes are predetermined, while in open systems, the outcomes are generated on the fly (Manovich 2011). Frasca (2003, 227) gives an example of this, "Unlike what would happen in storytelling, the sequence of events in a simulation is never fixed. You can play it dozens of times and things would be different. … Games always carry a certain degree of indeterminacy that prevents players from knowing the final outcome beforehand. To paraphrase Heraclitus, you never step in the same game twice." However, this is only true for what Frasca refers to as paidia games (e.g. Strikeman is the example Frasca refers to), not ludus games like Tetris or Street Fighter (see page 131 for more on paidia and ludus games);

» **Deep versus shallow:** This refers to the complexity of the choices in a structure. In shallow structures, the choices offered are simple and typically require less thought (e.g. 1 + 1 = ? or 'Are you hot? Yes or no?'). In deep structures the choices are complex—decision-making is difficult because there is no easy or obvious answer (e.g. deciding between solutions to address homelessness). (See also Norman 1988);

- **Wide versus narrow:** This refers to the breadth of choices in the structure—wide structures offer a large number of choices, while narrow structures offer a limited number. (See also Norman 1988);
- **Instrumental versus enactive:** Instrumental interactivity refers to "modalities which are deployed as a mechanism for exploring 'content'," while enactive interactivity refers to "modalities which themselves contribute to the accumulated meaning or experience of the work". (Penny 2011)

An experience-based perspective should be used with interactivity as a common lens

Having established in "Aesthetics, experience, and interactivity" on page 196 that experience should be placed at the centre of discussion, the next logical step would be to shift the perspective of interactivity from being solely media-based or technology-based to being experience-based. This is because an experience-based perspective would allow all experiences—both real and virtual—to be held in the same regard. The adoption of an experience-based perspective has been discussed by Biocca (2013) and Steuer (1992)[99]. Steuer (1992) argued for the rejection of the technological definition of virtual reality, declaring that virtual reality be defined in terms of telepresence because this would allow it (and other newly developed technologies) to be compared to other types of mediated experiences. This would also enable virtual reality to be thought of as "an experience, rather than a machine" and shift "the locus of virtual reality from a particular hardware package to the perceptions of an individual", such that "dependent measures of virtual reality must all be measures of individual experience" (79).

As such, by providing a common reference point, an experience-based persective can allow for mediated experiences to be compared and contrasted with non-mediated experiences, and newer technologies with older ones. This is particularly crucial today as the line between mediated and non-mediated experiences becomes increasingly blurred. Mobile technology, for instance, allows us to participate in mediated and non-mediated experiences simultaneously (e.g. chatting to a friend on Facebook while having a drink at a café), while virtual reality

[99] See "Experiences and interactivity" on page 106.

simulations allow the mimicry of non-mediated experiences in a mediated environment. The multifarious nature of content—it appears in and across a variety of formats and platforms, both real and virtual[100]—is also better served by an experience-based perspective as it is more versatile and inclusive.

At the same time, it is proposed that interactivity itself needs to be used as a basis for comparison as well. After all, as pointed out earlier, interactivity is inherently present in any experience (page 198), including both technology-based narrative experiences involving computer simulation technologies and real-world experiences involving no technology at all. Examining experiences in terms of the interactivity they contain means that different experiences can be compared on an even level. More specifically, this would enable the dimensions of interactivity present in an experience to be identified and the relationships between these dimensions to be explored in more depth, as well as enable different experiences to be compared and discussed. This combinative approach could also promote a greater understanding of immersion and presence. For instance, it could be used to investigate the correlation between the likelihood of immersion or presence in relation to how closely the interactivity in a narrative experience (virtual reality or otherwise) resembles the interactivity present in a real-life experience.

Benefits aside, the use of interactivity in conjunction with an experience-based perspective is challenging because it is in uncharted territory. The challenges involved in the shift to this approach are significant; the magnitude of this can be compared to the shift from a narrative-based perspective to an experience-based one. In reference to the latter, Frasca noted that "we are so used to see [sic] the world through narrative lenses that it is hard for us to imagine an alternative" and so "it is easier to try to apply narratology, which most researchers are already familiar with, than starting from scratch from [sic] a whole new approach" (Frasca 2003, 224). Likewise, the shift to combining interactivity with an experience-based perspective requires a significant adjustment. This adjustment can be made easier by explaining it within a recognisable context, such as video games.

[100] "In short, the interface is always at an information transformation point where narrative structure is changed into narrative experience as it moves from one form to another, from one system to another system, as from the 'bits' inside the computer to the 'meanings' interpreted by the user, from the analog [sic] world to the digital world, from cyberspace to physical space, or from one code (e.g., spoken language) to another code (e.g., written language)." (Biocca 2013, 107)

Video games are essentially a computer simulation technology[101] that combines narrative, media, experience and interactivity. Early video games grappled with the difficulties in their attempts to combine narrative with computer-based interactivity[102] and its status as a form of new media, while interactivity was primarily considered from a technology-based or media-based perspective, depending on whether the discussion was conducted by computer engineers or media theorists. These two perspectives have dominated over the last two decades as the focus remained on improving computer technology and on the impact of the resulting new media on society. Although the experience-based perspective gained some traction during the same period—in part due to the formation of new disciplines such as interaction design and experience design—interactivity continued to be viewed as a technological characteristic.

Today, many of the earlier technological difficulties have been addressed. This can be seen in a quick comparison between the 2002 version of *Grand Theft Auto*[103] (*Grand Theft Auto: Vice City*) and the 2014 version (*Grand Theft Auto V* or *GTA V*). The 2002 version, *Vice City*, was released as a single-player game with limited narrative and interactive potential. Control rested largely in the hands of the game creators—although players could interact with other characters in the game, all of those players were non-player characters (NPCs). Faster computer hardware and Internet connection speeds, as well as advancements in 3D animation software and techniques, made a huge difference to the 2014 version, *GTA V*. This contributed hugely to improving the overall interactivity of the game because it resulted the following features:

» players could play in first-person view (earlier versions only allowed a third-person view);
» non-player characters (e.g. cops, pedestrians and animals) behaved and responded more realistically due to improved artificial intelligence;
» increased control over customisation of the player's character (i.e. appearance, genetic heritage, etc.) and its possessions (i.e. the ability to make car modifications, purchase property, and trade on the stock market); and
» randomised dynamic missions were introduced.

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[101] Computer simulation technologies have been described as having the ability to "alter representational techniques and simulate physical spaces, social interactions, and the mental states of characters" (Biocca 2013, 98).

[102] "Video game designers have searched for decades for a way of bringing together the pleasures of stories and 'interactivity.' As Lev Manovich states, 'Interactive narrative remains a holy grail for new media.'" (Frasca 2003, 228-229)

[103] The *Grand Theft Auto* series is generally classified as an action sandbox video game, although in some versions players are required to complete missions to unlock sections of the world.

Although many of the earlier technological difficulties have now been addressed, this has not changed much with regard to the media-based perspective since the media format itself essentially has not changed. At the same time, the technology-based perspective—which typically views interactivity as simply a characteristic of technology—limits discussions to *how* interactive the game is or *how much* interactivity is in the game. Here is where using interactivity in conjunction with an experience-based perspective can be beneficial. This combinative approach allows for the deconstruction of the interactivity within experiences to determine *what kind* of interactivity is in the game and subsequently *how interactivity works in the production of experience*. For example, this could promote discussion and understanding in relation to how and why the online version of *GTA V* (called *GTA Online*[104]*)* feels more like a real-life experience than the non-online version.

Potential interactivity is distinct from perceived interactivity

In "Sohn's views on interactivity" on page 72, Sohn's (2011) proposition that interactivity relates to "a user's *perceptual experience* rather than a technological attribute" (1322, emphasis in the original) was presented. This notion of perceived interactivity is adopted here, with the addition of one other: potential interactivity. Potential interactivity is understood here as the potential or intended interactivity of a designed experience. This is largely used in the context of learning experience design, but can be more broadly applied to any designed experience. There is a need to distinguish between actual perceived interactivity and potential interactivity because this allows us to engage in discussions about whether a designed experience is successful; success is seen as the alignment of the potential interactivity of an experience (or the designer's intended interactivity) with the users' perceived interactivity.

Emotion, aesthetics, learning, and interactivity

The insights relating to emotion, aesthetics, learning, and interactivity are presented here. These are derived from "Learning and education" and "Emotion, learning, and aesthetics". Here the knowledge involving learning and aesthetics is viewed in conjunction with the interactivity section. The following insights were identified:

» Experience and interactivity produce learning;

[104] This online version allows players to play with up to 30 other real-life players. It functions in a similar way to MMOs (Massively Multiplayer Online games, also known as MMOGs), which led to *GTA Online* being described as an MMO or MMO-equivalent. See http://massivelyop.com/2015/04/24/gta-online-all-the-open-world-feels-none-of-the-mmo-grind/ for one example.

» Interactivity aesthetics can affect learning; and

» Emotion, aesthetics, learning, and interactivity are all connected.

Each of these insights is discussed and explained below.

Experience and interactivity produce learning

In traditional formal education, those interested in how learning takes place generally tried to understand the relationships between learning situations and any resulting changes in behaviour (or lack thereof). Gagné (1985, cited in Gagné et al. 2005, 4) called these relationships "conditions of learning". Gagné et al. (2005, 4) explained that the conditions of learning may be "both external and internal to the learner", and that these can be designed to make learning occur[105]. Up until recently, instructional design sought to provide the necessary conditions of learning but tended to use systems-based approaches to learning. Gagné et al. (2005), in particular, based their approach on Atkinson an Shiffrin's stage theory model, which saw learning as "information processing that consists of a number of stages between perception and memory", while admitting that they adopted this model because it offered some useful insights but also because they "don't really know exactly how the brain works" (7).

Recent neuroscientific research highlighting the importance of emotion in cognition[106] (and, by association, learning) along with society's increasing focus on acquiring experiences over products[107] and the acceptance of experience design as a design discipline appears to have coincided with—and may even have influenced—the pedagogical shift from content-based learning to experience-based learning[108]. This has resulted in less traditional types of learning, including experiential learning, gaining popularity. The move toward learning from—and through—experiences is nothing new. It could even be seen, in a sense, as a return to how we once learned and have always learned. In cultures where formal education is absent, such as hunter-gatherer cultures, for example, learning occurs much as it has been for centuries: primarily through real-life experience and as a result of learners interacting with their physical surroundings (Gray 2008a). This differs dramatically from traditional formal education settings, where learning generally seen as the desired and intended result of learners interacting with (often abstract) information. What is common between these interactions, however, is that

[105] This division between external and internal mirror the externalist and internalist approaches to aesthetic experience discussed on page 32, and are applied in the model of interactivity.

[106] See"Emotion, aesthetics, learning, and interactivity are all connected" on page 208.

[107] See "Experience is of primary importance" on page 196.

[108] See "Learning and education" on page 109.

they all involve interactivity between the learner and one or more of the following—an object, an animal, a person, an environment, or information. This suggests that, in order for learning to occur, there must be interactivity.

Interactivity aesthetics can affect learning

If interactivity produces learning, it makes sense then that changing the aesthetics of that interactivity can affect the 'look and feel' of the conditions of learning—by changing the meaning of words, images and behaviour. This is why different forms of written communication 'look and feel' different, even if they all contain the same written content; they have different interactivity aesthetics. Compare a hand-written letter, an email, and an SMS[109], for instance. All of these involve two-way writing, but each of these media formats require different ways of using language (i.e. length of sentences, types of words used, the spelling of words). This means that the writing format and style has to change with each medium in order to communicate the same meaning; it also means that if one were to write exactly the same thing in each medium, it would have a different meaning.

One example of this relates to the use of punctuation. Sternbergh (2014) described how the exclamation point went from being used by earlier generations to indicate "excitement … vehemence or volume" to being used in the 21st century as a form of ironic expression—"the punctuational equivalent of a smirk"—used to indicate excitement with the lowest possible amount of enthusiasm. This evolution reflects the aesthetic changes in the way we interact through writing. A more recent aesthetic change, however, is the introduction of visuals in written communication—in the form of emoji. Not only has this changed the meaning of words and symbols[110], it has also changed how we use words and symbols.

Emoji allow for the softness of genuine emotion to shine through while reducing some of the awkwardness of expressing such emotion. This ability of emoji to 'soften' text messages (e.g. SMS) has contributed to its popularity. Sternbergh (2014) gave several examples of people explaining how emoji "soften" what is written, including 20-something year old Alice Robb, who said emoji "allowed us to communicate without saying anything, saving us from spelling out any actual sentiments." Essentially, the introduction of emoji has changed the interactivity aesthetics of text messaging, and in turn, the change in interactivity aesthetics indirectly affects

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[109] SMS stands for Short Message Service, and is a text messaging service commonly used on mobile phones.

[110] This can also be called semiotic meaning. Semiotics refers to the study of the use and meaning of symbols.

literacy. As Mimi Ito, a cultural anthropologist at UC Irvine, noted, “when people are given the capacity to communicate in these ways [via emoji], they’re picking them up and developing whole new forms of literacy” (Ito, quoted in Sternbergh 2014).

Emotion, aesthetics, learning, and interactivity are all connected

As discussed in “Emotion and learning” on page 148, although the ancient Greeks understood the role of emotion in memorisation (Yates 2014), emotion was largely neglected as a topic of research in learning up until recently. The renewed interest in the relationship between emotion and learning can partly be attributed to neuroscientific research (e.g. Damasio 2004) that showed the significant influence of emotions on our thoughts and our behaviour—emotion is “not a luxury,” but is “indispensible for survival” (Damasio 2004, 49). At the same time, although the relationship between emotion and aesthetics has been recognised by those in the arts and humanities for some time, the relationship between aesthetics and learning has received much less attention. Additionally, given that there are obvious relationships between emotion, learning, and aesthetics, it is odd that there is not more knowledge and research available on the relationships between all three[111]. In response to this gap, this research seeks to offer a means of articulating these relationships.

[111] One might suggest that the existence of knowledge silos within disciplines limits the exploration of these relationships as it discourages the interdisciplinary thinking required.

Requirements of the model of interactivity

As pointed out in "A definition of interactivity aesthetics", interactivity and interaction are considered to be distinct concepts. Thus, although the literature review showed there was research that focused on the relationship between interaction and aesthetic experience, the relationship between interactivity and experience was not really explored, given that interactivity is not equivalent to interaction. As such, there is currently no means of establishing the interactivity aesthetics of an experience. Thus, it is proposed here that a tool for visualising the interactivity in experiences be created for this purpose, and to accomplish this it should be able to be used to:

» identify the different dimensions of interactivity present during a learning experience and the relationships between these dimensions;
» compare the interactivity present during different learning experiences; and
» compare the learning experience designer's intended interactivity with the learner's actual perceived interactivity.

It is proposed here that this tool take the form of a visual model. This is because a visual model would be the most effective means of displaying the various dimensions of interactivity, especially since the literature review highlighted the existence of a general bias toward the visual at the expense of other sensory modes. A visual model is ideal for displaying complex concepts—as well as the relationships between concepts—such that they can be viewed at a glance. Clemens stated that although conceptual knowledge is typically expressed using only words, the meaning behind the words is often "*inherently visual*" (Clemens 2004, emphasis in the original). As such, Clemens (2004) suggested that conceptual knowledge—including mental models—is better represented using visual models instead of other methods, such information visualisation or technical illustration[112]. It is recommended that other formats (suited to other sensory modes) be introduced at a later stage should the need arise.

Accordingly, considerations must therefore be made with regard to the requirements of this visual model. These requirements include the general qualities the model must possess as well as the functions it must perform in order to effectively map the interactivity in an experience.

General qualities of the model

Two main qualities are deemed necessary for the model to work as intended:
» The model has to be versatile; and
» The model has to be learner-centred (as opposed to educator-centred or content-centred).

First, the model must be versatile because if all experiences are aesthetic experiences, this must include learning experiences as well. Furthermore, since learning experiences today can occur in a broad range of formats (i.e. virtual, real-life, or a combination of both), one must be able to apply the model to all experiences in order to determine the interactivity aesthetics of a learning experience. It is particularly important that the model of interactivity be versatile enough to be used to map the interactivity present in our interactions not just with digital devices, but non-digital objects, environments, and people as well. On one hand, this is partly because there are signs that we are beginning to consider the virtual and imagined worlds as part of the real world. Future Lab, Lego's research and development team, found that "kids no longer make meaningful distinctions between digital play, like *Minecraft*, and physical play, like snapping together a Nindroid MechDragon … out of Legos" (Ringen 2015). On the other hand, versatility can also increase the longevity of the model. This means that the model of interactivity should not only apply to past and current technologies and realities, but also future ones. Longevity of use is important for the model of interactivity to be truly useful.

Second, if the learner is to be at the centre of the learning experience, the model of interactivity must be able to depict perceived interactivity (i.e. interactivity from the learner's perspective). This challenges the concept of aesthetic distance that is often discussed in interactive art. It would also appear to signal a departure from the interpretation of interactivity typically found in human-computer interaction and instructional design, where interactivity is primarily used

[112] Clemens (2004) also suggested information visualisation is best used to render quantitative data and technical illustration to render physical objects.

to describe the interactive features of digital devices. On the contrary, however, to achieve versatility in the model it is arguably necessary to combine both concepts of interactivity—as a quality of an interaction (perceived interactivity) *and* as a quality of a technology or device. Having a model of interactivity that can clearly identify what dimensions of interactivity are needed and/or are present in a learning experience would help in two ways: first, it addresses the tendency to focus on technology, media format, or content type (e.g. images versus text), which can distract from the real problem of how to best combine these to optimise learning for the learner; second, it alleviates some of the uncertainty and apprehension surrounding the use of technology in education.

Functions of the model

Four functions of the model are outlined here. These are based on the literature review and the key insights that were derived from it. These functions and their underlying concepts are shown in Table 1. This is followed by a discussion of each function and its underlying concept.

Function #1: Can be used to map both the potential interactivity (intended and unintended) and the actual perceived interactivity of an experience

It is proposed that the model should be designed in such a way that it is able to map the potential interactivity as well as the perceived interactivity of an experience. Furthermore, the development of the model should be based on the assumption that potential interactivity and actual perceived interactivity are equally important. This approach is influenced by Sohn (2011) and Steuer (1992). Sohn (2011) proposed that it is important to consider both the potential interactivity (this includes the interactivity inherent in the particular media format) and actual interactivity of an experience as perceived by the individual who is experiencing it (see also page 104). Separately, Steuer (1992, 79-80) declared, “First-person experiences in the real world represent a standard to which all mediated experiences are compared, either mindfully or otherwise: Face-to-face interaction with other humans is used as a model for all interactive communication (Durlak, 1987)”. Steuer (1992, 80) also stated that “telepresence is a function of both technology and perceiver”. In other words, telepresence involves not only the use of technology (in the form of media) to generate an experience, it also requires also one or more individuals to perceive the experience.

Thus, the model must be able to: (1) map an individual’s actual perception of an experience; (2)

map the unintended potential interactivity of the same experience; and (3) where applicable, map the intended potential interactivity as planned by the designer of the experience. Potential interactivity refers to the interactivity that is potentially present in an experience. Potential interactivity can be intended or unintended. Intended potential interactivity relates to the interactivity present in an experience that has been purposefully designed to contain particular dimensions or sub-dimensions of potential interactivity. Unintended potential interactivity, on the other hand, relates to the interactivity present in an experience that has not been designed. Perceived interactivity is the interactivity that is perceived by the person who engages in an experience. A person's perceived interactivity of an experience may not necessarily mirror the potential interactivity of that experience.

Table 1: Correlation between the key concepts and the functions of the model of interactivity

Function of the model	Underlying concept
Able to show both the potential interactivity (intended and unintended) and the actual perceived interactivity of an experience.	Potential interactivity is distinct from perceived interactivity.
Able to show the interactivity in all kinds of experiences, including (but not solely) learning experiences.	Experience is of primary importance; aesthetics is inherent in all experiences; and experience involves interactivity.
Able to show the interactivity that occurs internally and externally.	Emotion, aesthetics, learning, and interactivity are all connected; emotion, sensory perception, behaviour, and thought are all connected.
Able to show the different dimensions and sub-dimensions of interactivity, and the relationships between these.	The dimensions of interactivity are different from the characteristics of interactivity.

Function #2: Can be used to map the interactivity in all kinds of experiences, including (but not solely) learning experiences

At the end of "Technology and aesthetics", the dialogical approach recommended by McCarthy and Wright (2004) was their attempt to restore "the continuity between the aesthetic experiences of designing technology and living with it" (193). In the same vein, this research aims to restore the continuity between the planned learning experiences that are designed for specific purposes and the unplanned learning experiences that occur in our daily lives as a matter of course. This dialogical approach is adopted here because it reflects the dialogical nature of interactivity. To achieve this, it is necessary for the model to work with both the ordinary everyday experiences that constitute most of the unplanned learning experiences we have and the planned learning experiences that generally take place in formal education contexts such as school and university.

Function #3: Can be used to map the interactivity that occurs both internally and externally

The model must address the role of technology and the perceiver, and take into consideration the internal activity occurring within the perceiver, as well as the activity that occurs when the perceiver interacts with technology. This line of thinking is influenced by the internalist and externalist approaches to aesthetic experience discussed in "Internalism and externalism" on page 36, as well as Sohn (2011) and Steuer (1992). Sohn noted that there were relationships between sensory perception, cognitive understanding, and behaviour. Sensory perception and cognitive understanding can be said to occur within the perceiver, while behaviour is where the perceiver physically interacts with the surrounding environment. Steuer also mentioned sensory perception and cognition, and discussed external aspects such as space and dimensionality, time, media, and social interaction.

In the context of this research, the interactivity that occurs internally (within the person) is therefore categorised to as 'internalist', while the interactivity that occurs between the person and the external world is categorised to as 'externalist'. At the same time, the presentation of internalist and externalist interactivity uses a pragmatist approach—in other words, they are presented as two connected parts of the whole model.

Function #4: Can be used to map the different dimensions and sub-dimensions of interactivity, and the relationships between these

In order to have a deeper understanding of interactivity, it is necessary to identify the different dimensions and sub-dimensions[113] (including the perceptual systems) that are simultaneously at play. This is derived from Steuer's observation that changes in sensory breadth and depth could affect presence:

> The simultaneous engagement of multiple perceptual systems is an extremely effective means of engendering a sense of presence, even if some stimuli are quite low in depth … It is likely that breadth and depth are multiplicatively related in generating a sense of presence, with each dimension serving to enhance the other. The exact nature of this interaction clearly warrants further study. (Steuer 1992, 84)

[113] For the purposes of discussion, the different types of interactivity are referred to as dimensions, while the subsets of each dimension are called sub-dimensions.

Additionally, having established the need to delineate between internalist and externalist interactivity, it is also necessary to identify which dimensions are internalist and which are externalist.

Dimensions and sub-dimensions of interactivity

The following dimensions were considered for inclusion in the model of interactivity after the literature review and initial testing of Versions 1 to 3 of the model: emotion (or affect), sensory perception, brain function, movement, space and dimensionality, time, media, and social interaction. Of these, emotion, sensory perception, brain function, movement, space, media, and social interaction were selected for inclusion into Versions 4 and 5 of the model, and eventually, the final version. Emotion is included but as a token dimension with no actual sub-dimensions because it is believed that the complexity of the emotional spectrum alone warrants a stand-alone model that can perhaps be used in conjunction with the model of interactivity. Although time and dimensionality were considered, they were not included in the final version due to concerns that this would make the model of interactivity too complex. It is possible that time and emotion will be included in future versions of the model. For now, however, this is considered beyond the scope of this research.

Sensory perception

The evidence cited in relation to the sensory dimension was primarily related to the visual sensory mode. Animated visuals, for instance, were perceived to be more interactive, as were visuals that were perceived as being more vivid[114]. Unable to determine "what kinds of sensory information help elevate perceived interactivity and to what extent", Sohn concluded that further empirical research was required (1326-1327).

The other sensory modes identified for inclusion in the model are derived from the five common recognised senses: sight, sound, taste, smell, touch. These same modes were identified by Gibson, who identified "five distinct perceptual systems: the basic orienting system, which is responsible for maintaining body equilibrium; the auditory system; the haptic, or touch, system; the taste-smell system; and the visual system"[115] (Gibson 1966, cited in Steuer 1992, 81). These five modes were also used in Dunn's Sensory Mapping infographic (page 159). Given that the model of interactivity is in the early stages of development, this was seen to be adequate in

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[114] See also Steuer (1992) on vividness and interactivity, on page 65.

[115] Gibson also stated that "[inputs] to several of these systems from a single source can be considered informationally equivalent" (Gibson 1966, cited in Steuer 1992, 81).

the context of this research. However, this research recognises that more than five senses have been identified (Jarrett 2014) and it may be necessary to include these in future versions of the model.

Brain function

When discussing the semantic dimension, Sohn mainly focused on how we derive meaning from our interactions with media or other people. A medium might be perceived as interactive, for example, if it offers "vivid sensory information" (as mentioned above) along with "personally relevant messages (e.g. 'Welcome back, Jane!')" (1327). In the semantic dimension of interactivity, meaning is "conveyed not only by texts, but also by non-verbal elements like symbols or icons" (1328). However, perceived interactivity is not only affected by meaning; meaning must also be accompanied by relevance (Rafaeli 1988, cited in Sohn 2011, 1327) and "reciprocally sustained involvement" (Goffman 1957, quoted in Sohn 2011, 1327).

Movement

Behavioural engagement, Sohn noted, has a significant influence on perceived interactivity (1328). With the behavioural dimension, Sohn explained that it "focuses on the extent to which users perceive they can behaviorally [sic] engage in an interaction situation" (1329, emphasis in the original). He also pointed out that some scholars have linked behavioural engagement to the amount of control the user has during the interaction, but expressed his disagreement, stating, "control is an outcome of reciprocal interaction, not its intrinsic aspect—the more reciprocal an interaction becomes, the greater control an actor has over the interaction process, not vice versa". He also clarified that the behavioural dimension is not the same as affordance, but rather a subset of it; affordance refers to all the possible actions the user perceives as being available, while the behavioural dimension is focused only on those related to behavioural engagement. (1329)

Space, dimensionality, and media

In relation to space, dimensionality, and media, Steuer (1992, 87) made clear distinctions between virtual reality, "real reality", and dreams (or hallucinations):

> If virtual reality is defined in terms of telepresence, then its locus is the perceiver. Under this definition, virtual reality refers only to those perceptions of telepresence induced by a communication medium. Therefore, virtual reality can be distinguished from both purely psychic phenomena, such as dreams or hallucations (since these experiences require no perceptual input at all), and from the real reality as experienced via our unaided perceptual hardware (since virtual realities, unlike real realities, can be experienced only through a medium).

Thus, Steuer distinguishes virtual reality from real life and dreams using two factors: perceptual input and use of media. Here, this research deviates slightly. Rather than focus on perceptual input, the focus is on the presence of perceptual activity—interactivity that relates to perception.

For the model to be adequately versatile and inclusive, it must therefore be able to allow each of the abovementioned experience types—virtual reality, real life, and dreams—to be mapped. Looking at these three scenario types in this way, two factors can be used to distinguish between them: (1) real versus virtual[116] (i.e. is the experience occurring in a real-life physical environment or a virtual one); and (2) mediated versus non-mediated (i.e. does the experience occur with or without the use of media). A virtual reality experience would thus be seen as occurring in a virtual space, using media; a dream experience would be occurring in a virtual space, without using media; and a real-life experience would be seen as occurring in a real space, without using media.

Social interaction

In relation to social interaction, Steuer (1992, 87) wrote, "The number of actors present in a virtual world can also affect the perception of telepresence," suggesting that the qualities of social interaction (e.g. number of participants, location, use of media, etc.)—what I refer to as social interactivity—affect presence.

Relationships between the different dimensions and sub-dimensions of interactivity

Once the dimensions and sub-dimensions are established, mapping those present in an experience can then inform our understanding of how different combinations and configurations of dimensions and sub-dimensions can influence the aesthetics of the interactivity in the experience. Combination refers to the set of dimensions and sub-dimensions of interactivity that are present in an experience, while configuration refers to the relationship between these dimensions and sub-dimensions. The configuration of interactivity is as important as the combination. Levinson's observation about seeing and hearing demonstrates why this might be:

> Seeing without hearing, hearing without seeing: the two processes seem much the same, yet the first shrivels in the face of seeing-and-hearing competition, and the second becomes the locus for one of the most successful popular cultures in

[116] Here the term virtual is not used as it is in the term virtual reality, but rather to refer to a virtual space, as opposed to a real-life environment.

> our century. The two processes must thus be different in some fundamental way. (Levinson 2001, 98)

The neuroscientist Antonio Damasio also alluded to this. He wrote, "When we recall an object … we retrieve not just sensory data but also accompanying motor and emotional data … We recall not just sensory characteristics of an actual object but the past reactions of the organism to the object" (Damasio 2000, 161) This suggests a connection between the different dimensions and sub-dimensions of interactivity and that the relationships between them are of significance. The relationships between emotion, movement, thought, and perception (see Figure 19, page 187) were taken into account when considering the structure of the model of interactivity.

It is important to note here that the purpose of the model is not to identify a perfect configuration or combination of interactivity dimensions, since the perfect configuration or combination is relative to its purpose. Rather, the model is intended to function as a visualisation tool that can then subsequently be used for analysing experiences—for instance, comparing the interactivity of two or more different experiences to determine how they can be used in a complementary fashion, or identifying the interactivity dimensions of an experience to determine their suitability for a specific purpose (i.e. what combinations of interactivity dimensions are best for producing the illusion of presence, promoting rote learning, or promoting creative thinking).

To accomplish this function, a number of assumptions were made. Firstly, taste and smell were viewed as two distinct systems (although certainly it must be acknowledged that the two are interconnected). Secondly, for the purpose of simplicity, the "basic orienting system" described by Gibson was removed (see page 311 regarding its reintroduction in future research) and the model only addressed the five basic sensory modes. Thirdly, it was assumed that each type of sensory input, even if derived from a single source, was not necessarily "informationally equivalent" (Steuer 1992, 81).

In relation to the third point, more explanation is warranted. Steuer (1992) noted that the number of sensory dimensions present at the same time (sensory breadth) and the quality or resolution of each dimension (sensory depth) affected vividness (81). Specifically, simultaneously presenting different types of redundant[117] sensory input enhanced vividness,

[117] The use of the term redundant is not ideal, since one might argue that each type is important in a different way from the rest. It is assumed that the definition of this term—as it is used by Steuer (1992, 81-82)—is taken from the engineering definition (in this case, from the Merriam-Webster online dictionary): "a part in

since "the redundancy resulting from simultaneous activation of a number of perceptual systems reduces the number of alternative situations that could induce such a combination of perceptions, and therefore strengthens the perception of a particular environment" (81-82). Applied to this research, this suggests that the model needed to show which senses are being engaged simultaneously, and whether cognitive activity and motor activity are also present.

Building this function into the model would improve our understanding of presence. After all, Steuer proposed that the greater the sensory breadth (i.e. the more senses are engaged) of an experience, the more likely it is that a sense of presence will occur (82). He described traditional media (e.g. newspapers, television, film) as being "low in breadth, relying primarily on the visual and auditory channels", and goes on to list examples where attempts have been made to increase sensory breadth: in traditional media, such as the film *Polyester* (which introduced smell), and the films *Earthquake* and *The Tingler* (which introduced touch); in devices, such as "the Sensorama device developed by Mort Heilig", which "[utilized] four of the five senses[118] to simulate a motorcycle ride"; and in theme park attractions, such as the Star Tours and Body Wars simulators which "combine a motion platform with multichannel sound and film to simulate space travel and a tour through the human body, respectively", and the Pirates of the Caribbean ride, where "the smell of gunpowder is used to enhance the illusion of being in the midst of a battle". (82) Likewise, more recent media technologies—one of the most recent examples of this is probably the Oculus Rift—also seek to increase sensory breadth.

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a machine, system, etc., that has the same function as another part and that exists so that the entire machine, system, etc., will not fail if the main part fails". Nonetheless, one can see the logic behind using the term, since those who have visual or auditory impairment are still able to glean information about the environment using their other senses.

118 "Users see the Manhattan streets go by, hear the roar of the motorcycle and the sounds of the street, smell the exhaust of other cars and pizza cooking in the roadside restaurants, and feel the vibration of the handlebars." (Steuer 1992, 82)

05

DEVELOPING THE MODEL

Ideation, testing, and evaluation

In the process of developing the model of interactivity, five versions of the model were generated. Each succeeding version is a new iteration of the model. This section presents the these five versions. For each version, a short description is presented, followed by the tests of that version, its evaluation, and recommended changes.

Model of interactivity—Version 1

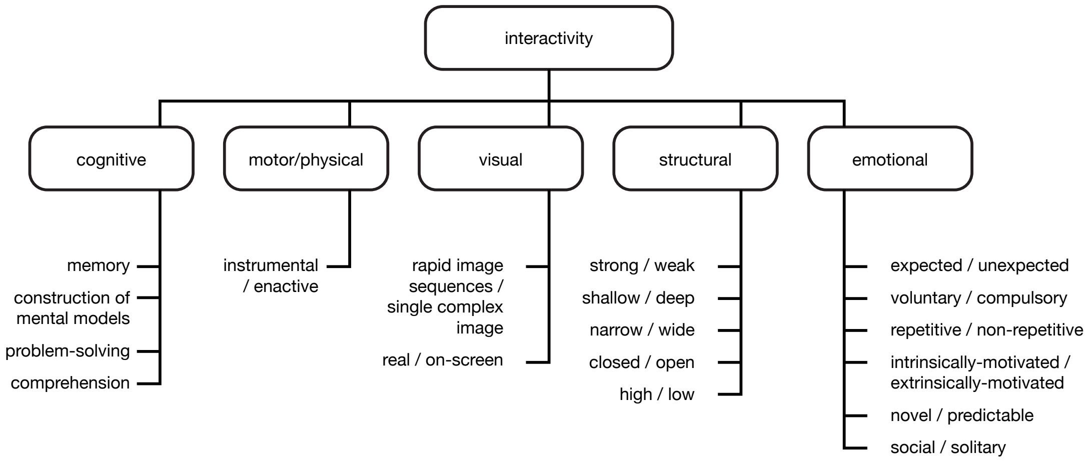

Figure 19: Model of interactivity—Version 1

Figure 19 depicts Version 1 of the model. In this iteration, several types of interactivity were identified based on the research gathered in the early stages of the literature review. These interactivity types are listed in Figure 19. Consideration was given towards how to group these interactivity types in Version 1. Specifically, these interactivity types were taken to be sub-dimensions that fell under a broader set of dimensions—five broader dimensions of interactivity were eventually identified. These five dimensions were: cognitive, motor/physical, visual, structural, and emotional. The five dimensions functioned as categories, so a format commonly used for categorisation was chosen—a vertical tree diagram. The sub-dimensions of interactivity in each dimension were marked with a tick (✓) if they were present in a given experience and in the case of absence no tick was added. The two main issues with this version were that it incorrectly conflated the dimensions of interactivity with characteristics of interactivity and it did not show the relationships between the five dimensions.

Model of interactivity—Version 1 testing

Version 1 of the model of interactivity was tested only on Scenario 1. In Version 1, the interactivity types or dimensions that are present are marked with a tick and those that are absent are not marked. The results are described below.

Scenario 1: Eating a meal with family in real life

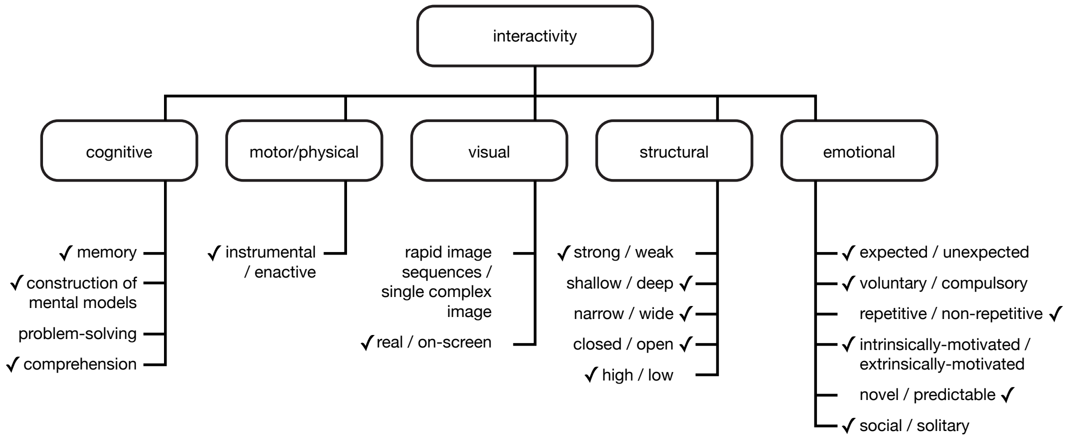

Figure 20: Test of Version 1 on Scenario 1 (Eating a meal with family in real life)

The test of Version 1 of the model on Scenario 1 is shown in Figure 20. The cognitive interactivity during a meal involves the use of memory (i.e. when remembering previous meal experiences), the construction of mental models (i.e. if new foods are encountered or new topics of conversation are discussed), and comprehension (i.e. to understand the conversation during the meal). The motor/physical interactivity is instrumental—it allows the 'content' (in this case, the food) to be explored. It is not enactive since the interactivity with the meal does not contribute to the meaning of the meal. (At this point, it became apparent that it would be more appropriate to place enactive with comprehension, even though it is the opposite of instrumental.) The visual interactivity is real, rather than on-screen, thus rapid image sequences and single complex image do not apply as they only apply to media-based scenarios. The structural interactivity is strong (i.e. the person has a significant effect on the experience), deep (i.e. the person can engage in many successive interactions), wide (i.e. the person has a wide range of interaction options available), open (i.e. the interaction is largely open-ended rather than pre-determined), and high (i.e. the person has high control over what his or her actions during the experience). Under emotional interactivity, the interactivity types present were:

expected (i.e. the person knew what to expect from the experience), voluntary (i.e. the person was not forced to particpate in the experience), non-repetitive (i.e. the movements in this experience occurred naturally and were not repeated in a pattern), intrinsically-motivated (i.e. the person was not motivated by external factors to participate in the experience), predictable (i.e. the person was able to predict what would happen during the experience), and social (i.e. the person interacted with other people).

Evaluation of Version 1

The test of Version 1 on Scenario 1 showed that this version of the model was problematic and needed to be reworked. The categorisation of the interactivity types and the names of the dimensions had to be addressed, particularly those listed under emotional interactivity. The interactivity types under emotional interactivity were initially assigned there because of their potential to produce an emotional reaction. However, when the model was applied to Scenario 1, it became apparent that the categorisation of some of these was not appropriate. For example, the interactivity in Scenario 1 is largely expected—it is an experience that has occurred many times and the person knows what to expect—but this does not solely relate to emotional interactivity. It can also relate to visual, cognitive and motor interactivity as well. The same goes for the voluntary, non-repetitive, intrinsically-motivated, and predictable interactivity types. The expected and predictable interactivity types seemed too similar; on the other hand, the unexpected and novel dimensions indicated slightly different things.

Upon reflection, it was realised that these interactivity types were actually characteristics of interactivity rather than sub-dimensions of interactivity. The social/solitary interactivity types did not seem to align with the rest of these and seemed awkward being categorised under emotional interactivity—it later became apparent that this was because social interactivity was better classified as a separate dimension. Additionally, the use of the tree diagram and ticks was inelegant. The quantity of lines in the tree diagram made this version look visually 'cluttered' and the stacked vertical arrangement of the interactivity types was suggestive of a hierarchy when in fact there was none. The use of the ticks also added to the visual clutter.

Changes recommended for Version 2

Following the testing of Version 1, a number of changes were recommended for Version 2. These changes and the rationale for these changes are explained in the subsequent paragraphs:

» Categorise the interactivity dimensions as internalist or externalist;
» Rename emotional interactivity as affective interactivity;
» Change visual interactivity to sensory interactivity;
» Add creative interactivity and imaginative interactivity;
» Remove structural interactivity; and
» Remove all characteristics of interactivity.

Categorise the interactivity dimensions as internalist or externalist

Although it is proposed that the terms 'internalist' and 'externalist' be used in Version 2 to categorise the dimensions of interactivity, these terms are not used here in exactly the same way as in the literature review. Instead, these terms are used to articulate the contexts in which interactivity occurs. In total, interactivity is thought to occur as a result of from any of the following three interactions (see Figure 21):

» the interaction between the individual's brain and body;
» the interaction between the individual's brain and the world[119];
» the interaction between the individual's body and the world.

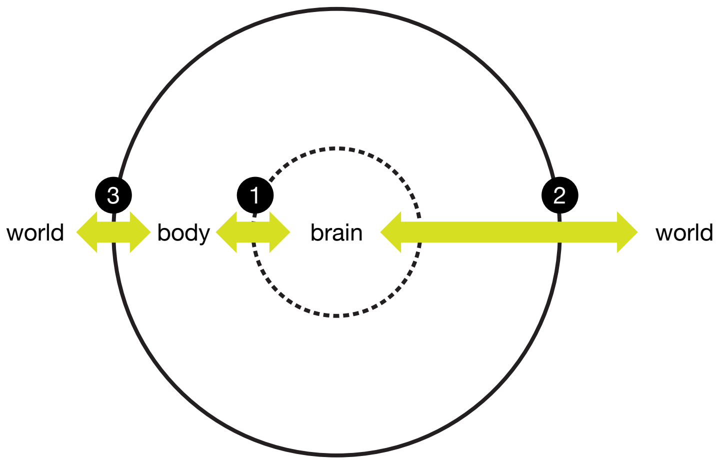

Figure 21: Interaction between body, brain and world

Thus, the term 'internalist' to refer to the interactivity occurring within the individual (between the individual's brain and body) and the term 'externalist' to refer to the interactivity occurring outside of the individual (between the brain and the world, and between the body and the

[119] This is partly based on what Jan Koenderink said, "The mind is far from being the product of the brain. It derives from the interaction of the embodied brain and the world." (Lavazza and Manzotti 2011, 509)

world). On one hand, the use of the term 'internalist' in this manner relates to neuroscience's view of internalism—"the physical basis of mental activity is taken to be inside the nervous system" (Lavazza and Manzotti 2011, 507)—since it nominates the physical location of the interactivity as occurring inside the individual. It also relates to the internalist approach to aesthetic experience in philosophy[120] which, in this context, refers to our interpretation of what the interactivity occurring inside a particular individual might feel like. The use of the term 'externalist', on the other hand, refers to that which occurs as a result of the individual's interaction with the world beyond the body. In relation to neuroscience's externalism, this means that the body is viewed as an extension of the mind; the mind is not limited to being seen as solely linked to the brain or nervous system. The term 'externalist' also references the externalist approach used in philosophy, which considers the epistemic or contextual aspects of the experience—Baofu (2009, 6) listed "the intention of the artist, biographical materials, cultural context, institutional norms, social structure, and moral themes" as examples of this.

Rename emotional interactivity as affective interactivity

This was changed because affect was a broader term that encompassed emotions, as well as feelings, expectations, and satisfactions[121].

Change visual interactivity to sensory interactivity

Since the visual sense is only one of a number of senses, it made sense to do this so as to include the other senses (i.e. auditory, gustatory, olfactory, and somatic).

Add creative interactivity and imaginative interactivity

After testing Version 1 on Scenario 1, it was noted that creative interactivity and imaginative interactivity could also occur, and that these were distinct from cognitive interactivity. Thus, it is recommended that these be added to Version 2 as dimensions.

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[120] See page 36.

[121] See page 203.

Remove structural interactivity

Structural interactivity was removed because it was determined to be a characteristic of interactivity, not a dimension.

Remove all characteristics of interactivity

It is recommended that the characteristics of interactivity be removed from the model of interactivity and that the model should focus on showing the dimensions of interactivity instead. Additionally, it is understood that the characteristics of interactivity are applicable to all the dimensions of interactivity.

Model of interactivity—Version 2

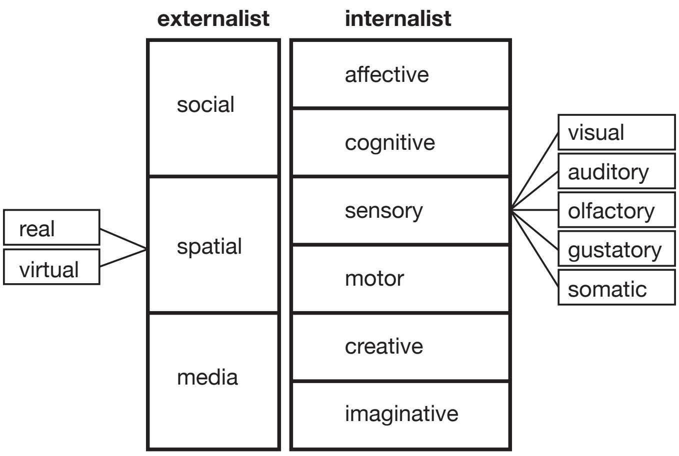


Figure 22: Model of interactivity—Version 2

Version 2 of the model (Figure 22) specifically addressed the issue of mixing characteristics and dimensions of interactivity that occurred in Version 1. To produce Version 2, Version 1 was reviewed and any characteristics of interactivity found in Version 1 were removed; Version 2 contained only dimensions of interactivity. At this point, additional information had been gathered as part of the literature review. Based on this additional information, nine dimensions of interactivity were identified.

The nine dimensions identified were: affective, cognitive, sensory, motor, creative, imaginative, social, spatial, and media. The spatial interactivity dimension was divided into two sub-dimensions: real and virtual. The sensory interactivity dimension was divided into five sub-dimensions: visual, auditory, olfactory, gustatory, and somatic. The nine dimensions were categorised as either internalist or externalist—the dimensions occurring within an individual were considered to be internalist, while the dimensions occurring between an individual and that which is external to the individual were considered to be externalist.

A different format for displaying the interactivity dimensions was tried in Version 2—a grid. The internalist dimensions were placed in a grid that was one box wide by six boxes tall, with each dimension in a separate box. The externalist dimensions were placed in a separate grid that was one box wide by three boxes tall. The sub-dimensions of the sensory and spatial dimensions were each placed in single boxes (one per sub-dimension), with lines linking them to the relevant dimension. A different method of indicating the presence of interactivity was also used—shading was now used instead of ticks. The boxes in the grid were shaded to indicate the presence of an interactivity dimension, or left unshaded to indicate absence.

Three main issues with Version 2 of the model were observed after it was tested. These issues largely related to the method of categorising the interactivity dimensions and sub-dimensions. Firstly, it was understood that cognitive, creative, and imaginative interactivity were each sub-dimensions of mental interactivity rather than stand-alone dimensions of interactivity. Secondly, it was determined that relevant sub-dimensions needed to be added to the affective interactivity, motor interactivity, media interactivity, and social interactivity dimensions in order for them to more accurately reflect the nature of the interactivity in those dimensions. Finally, the categorisation of the dimensions of interactivity as internalist and externalist was seen as needing further testing to determine its appropriateness.

Model of interactivity—Version 2 testing

Version 2 of the model of interactivity was tested on Scenarios 1 to 4. In Version 2, interactivity dimensions and sub-dimensions that are present are shaded and those that are absent are left unshaded. The results are described below.

Scenario 1: Eating a meal with family in real life

The test of Version 2 of the model on Scenario 1 is shown in Figure 23. The media, creative, and imaginative dimensions, as well as the virtual sub-dimension, are left unshaded because they are not present. No media is being used during a meal experience (although with smartphone use becoming more widespread, this is changing), there is no creative production, and there is no need for imagination to be used. The social, spatial, media, affective, cognitive,

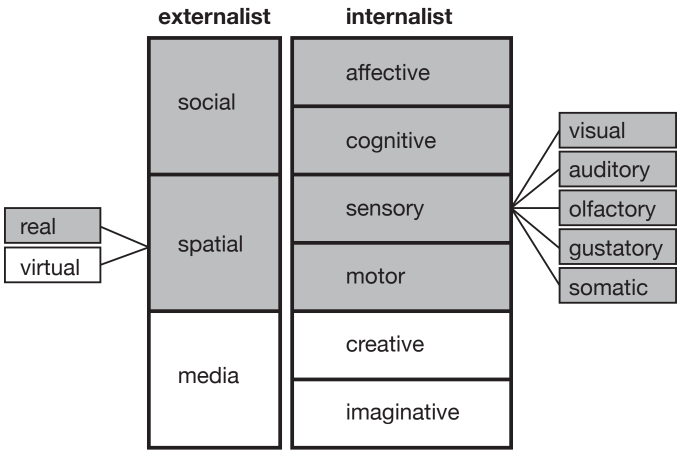


Figure 23: Test of Version 2 on Scenario 1 (Eating a meal with family in real life)

sensory, and motor dimensions along with the real, visual, auditory, olfactory, gustatory, and somatic sub-dimensions are all present and therefore they are all shaded. Social interactivity (i.e. social interaction with other people during the meal), affective interactivity (i.e. emotional responses to other people and to the food), cognitive interactivity (i.e. in order to make sense of what is being said, eaten, seen, etc.), and motor interactivity (i.e. holding utensils) are all present during a family meal. The meal experience is happening in real life, so both the spatial and real dimensions are shaded. All five sub-dimensions of sensory interactivity are present, so these are all shaded, along with the sensory dimension.

Scenario 2: Silent reading of the printed book *The Hundred-Foot Journey*

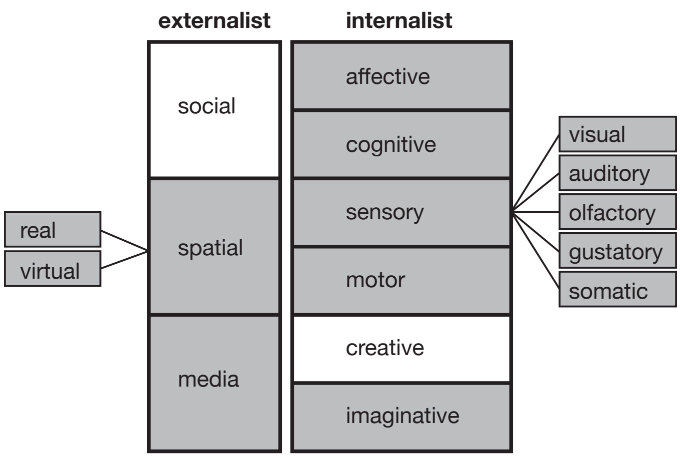


Figure 24: Test of Version 2 on Scenario 2 (Silent reading of the printed book The Hundred-Foot Journey*)*

The test of Version 2 of the model on Scenario 2 is shown in Figure 24. The social and creative dimensions are left unshaded because they are not present. Reading a book involves no social interaction or creative production. The spatial, media, affective, cognitive, sensory, motor, and imaginative dimensions are present, as are the real, virtual, visual, auditory, olfactory, gustatory, and somatic sub-dimensions. Thus, all these are shaded. Spatial interactivity is real, but in a sense, also virtual, since the reader might interact with the story virtually by using their imagination. Media interactivity is present, since a book is involved. There is affective interactivity (i.e. the reader gets emotionally engaged) and cognitive interactivity (i.e. the reader needs to use cognitive abilities to read the words and understand them), as well as motor interactivity (i.e. to turn the pages). Imaginative interactivity is present because the reader needs to use his or her imagination to picture the story in their minds, particularly since the book is a fiction story with a lot of descriptive language. There is sensory interactivity as well—visual interactivity (i.e. looking at the words), auditory interactivity (i.e. imagining the sounds of the characters voices), olfactory interactivity (i.e. imagining the smells of the food), gustatory interactivity (i.e. imagining the taste of the food), and somatic interactivity (i.e. touching the book's pages).

Scenario 3: Playing 3-on-3 basketball in real life

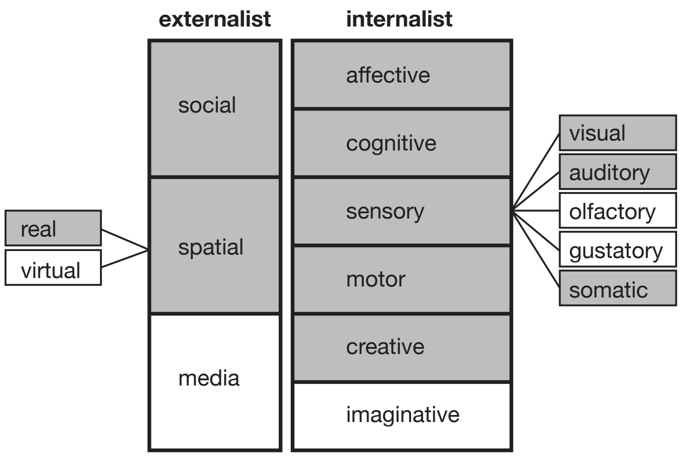


Figure 25: Testing Version 2 of the model of interactivity on Scenario 3 (Playing 3-on-3 basketball in real life)

The test of Version 2 on Scenario 3 is shown in Figure 25. The social interactivity dimension is shaded because 3-on-3 basketball involves social interaction with other players. Spatial interactivity is real rather than virtual, so both the spatial interactivity dimension and real sub-dimension are shaded. Affective interactivity is present (i.e. in the form of emotions such as anxiousness, excitement, etc.), as well as cognitive interactivity (i.e. remembering the rules of the game) and motor interactivity (i.e. running, passing the ball, etc.), so the affective, cognitive, motor dimensions are shaded accordingly. The sensory interactivity sub-dimensions that are present include visual, auditory, and somatic—these have been shaded. The creative interactivity dimension is also shaded since the player has to think of creative ways to get the ball past the opposing team and into the basket to score.

Scenario 4: Playing 3-on-3 basketball in the *Wii Sports Resort* game

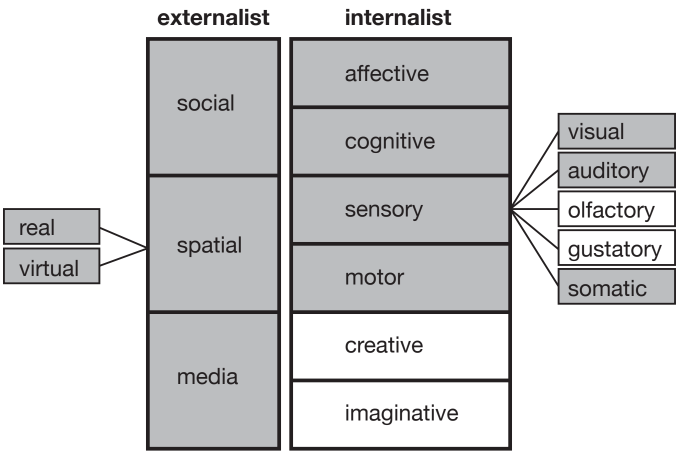


Figure 26: Testing Version 2 of the model of interactivity on Scenario 4 (Playing 3-on-3 basketball in the Wii Sports Resort *game)*

The test of Version 2 of the model of interactivity on Scenario 4 is shown in Figure 26. As in Scenario 3, the social, spatial, affective, cognitive, sensory, and motor interactivity dimensions are all present. The virtual and real spatial interactivity sub-dimensions are shaded since this experience occurs in both virtual space and real space. The media interactivity dimension is shaded due to a game console being used. The creative interactivity dimension is not shaded since the player scores by pressing the buttons on the game console controller in a set sequence.

Evaluation of Version 2

The second version of the model of interactivity was more user-friendly. It was much quicker to use, and also easier to 'read' (i.e. visually interpret). This was partly the result of the change from using ticks to using the shading of the relevant boxes to indicate when an interactivity sub-dimension was present. Affective (or emotional) interactivity was separated into a distinct dimension from social interactivity. Sensory interactivity was introduced to incorporate all the five basic sensory sub-dimensions. Spatial interactivity was introduced to distinguish between real and virtual experiences. Media interactivity was introduced to distinguish between mediated and non-mediated experiences. Creative interactivity and imaginative interactivity were introduced to the internalist category.

The Scenario 1 test was fairly straightforward and there were no issues with representing the interactivity present. However, the Scenario 2 test highlighted two issues with Version 2. Firstly, there was no way for the model to depict the relationships between different interactivity sub-dimensions—for example, to differentiate between sensory interactivity that is real (in the case of Scenario 2, visual and somatic) and imagined (in the case of Scenario 2, auditory, olfactory, and gustatory). Secondly, it also raised the question of whether imagined experiences can be thought of as occurring in virtual space.

Collectively, the Scenario 3 and Scenario 4 tests highlighted four issues. First, although the motor interactivity in Scenario 3 is different from that in Scenario 4, Version 2 does not allow for these differences to be displayed. Second, although the social interactivity in Scenario 3 is many-to-many and the social interactivity in Scenario 4 is one-to-one, this version of the model does not differentiate between the two. Third, when Scenario 4 is compared with Scenario 2, it is apparent that Version 2 does not allow for differentiation between different types of media (print versus digital). Lastly, as mentioned earlier with Scenario 2, there is no way to depict the relationship between spatial interactivity and other dimensions of interactivity (i.e. it is not possible to show whether a particular dimension of interactivity is occurring in a real or a virtual space).

Changes recommended for Version 3

Based on the evaluation of Version 2, four changes were recommended for Version 3. No changes were recommended to address the issue of depicting relationships between different sub-dimensions; at this point it was not yet known how this would be done. The recommended changes and the accompanying rationale for each of these are outlined below:

- » Add fine motor and gross motor sub-dimensions to the motor interactivity dimension;
- » Add one-to-one, one-to-many, and many-to-many sub-dimensions to the social interactivity dimension;
- » Add digital device, book, TV, film, radio sub-dimensions to the media interactivity dimension; and

» Change cognitive, creative, and imaginative interactivity dimensions to sub-dimensions under a new dimension—mental interactivity.

Add fine motor and gross motor sub-dimensions to the motor interactivity dimension

This will allow for motor interactivity that involves fine motor movement to be differentiated from motor interactivity that involves gross motor movement.

Add one-to-one, one-to-many, and many-to-many sub-dimensions to the social interactivity dimension

This will allow the model to differentiate between experiences that involve one-to-one social interaction (i.e. one person interacting with another person), as well as social interaction that is one-to-many (i.e. one person interacting with many people, where the many different people do not necessarily interact with each other) and many-to-many (i.e. many people interacting with each other).

Add digital device, book, TV, film, radio sub-dimensions to the media interactivity dimension

This will enable the model to differentiate between experiences involving different media.

Change cognitive, creative, and imaginative interactivity dimensions to sub-dimensions under a new dimension—mental interactivity

Since the cognitive, creative, and imaginative interactivity dimensions all occur inside the mind, it made sense to place them together as sub-dimensions under a broader dimension. This dimension was named the mental interactivity dimension because they all require mental activity.

Model of interactivity—Version 3

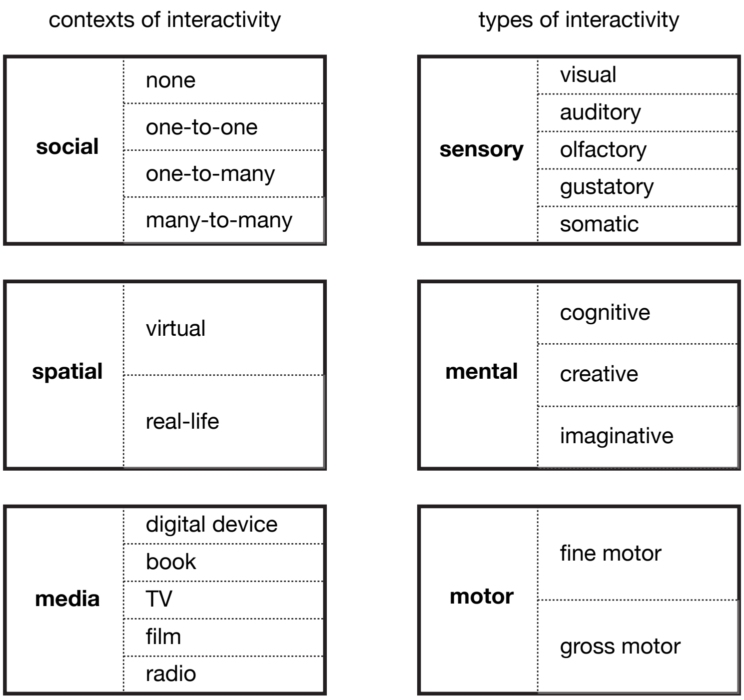


Figure 27: Model of interactivity—Version 3

In Version 3, the focus was on further refining the dimensions of interactivity. Figure 27 shows Version 3 of the model. Following the review of Version 2, the interactivity dimensions were grouped in a similar fashion, but the groups were renamed to see if a different method of categorisation would work better. The internalist dimensions of interactivity group was renamed types of interactivity, while the externalist dimensions group was renamed contexts of interactivity. This was done with the intention of clarifying the differences between the internalist and externalist interactivity dimensions. Affective interactivity was excluded in this version, primarily because it was still unclear how it should be divided.

Under contexts of interactivity, each of the three dimensions was further divided into various sub-dimensions. Social interactivity was divided into the following four sub-dimensions: none, one-to-one, one-to-many, and many-to-many. Spatial interactivity was divided into two sub-dimensions: virtual and real-life. Media interactivity was divided into five sub-dimensions: digital devices, book, TV, film, and radio. Under types of interactivity, motor interactivity was divided into two sub-dimensions: fine motor and gross motor. Cognitive, creative, and imaginative interactivity were grouped together under a new dimension: mental interactivity. Sub-dimensions were not introduced under affective interactivity here as the research conducted into emotions and affect at the time indicated that this was significantly complex and warranted a separate and more thorough investigation prior to inclusion. Sensory interactivity remained unchanged.

The method of shading boxes used in Version 2 was retained in Version 3 since this was observed to be quick and effective—the presence or absence of each of the various interactivity dimensions and sub-dimensions could be viewed at a glance. However, the layout of the boxes in Version 2 was adjusted in Version 3 such that the dimensions were separated into individual boxes. Each dimension was placed in the same box together with its relevant sub-dimensions, separated by dotted lines. The dimensions were placed in a column under the relevant category title, with the dimensions relating to the contexts of interactivity in the left column, and the dimensions relating to the types of interactivity in the right column.

After testing, three main issues with Version 3 were identified. Firstly, as with the earlier versions, it was primarily a binary system of visual representation—presence and absence could be indicated, but the amount or strength of the interactivity could not. Secondly, the renaming of the categories did not seem to improve clarity—if anything, it could be argued that contexts of interactivity might be more about the combination of the interactivity dimensions present, while types of interactivity could be used to encompass all the dimensions listed in Version 3. At this point, additional research also confirmed that the terms 'internalist' and 'externalist' were more suitable. Finally, this version still did not allow for the relationships between the dimensions and sub-dimensions to be depicted.

Model of interactivity—Version 3 testing

The changes recommended for Version 3 were applied. These changes improved the categorisation of the various interactivity dimensions and sub-dimensions. Although it was observed during the testing of Version 2 that the model needed to show the relationships between the interactivity sub-dimensions, this issue was not resolved in this version as the focus was on the categorisation of the interactivity dimensions and sub-dimensions.

Version 3 of the model of interactivity was tested on Scenarios 1 to 5. In Version 3, the interactivity sub-dimensions that are present are shaded and those that are absent are left unshaded. The interactivity dimension boxes are not shaded at all and function more as labels; it is assumed that if one or more sub-dimensions are shaded then the dimension is considered to be present. The results are described accordingly.

Scenario 1: Eating a meal with family in real life

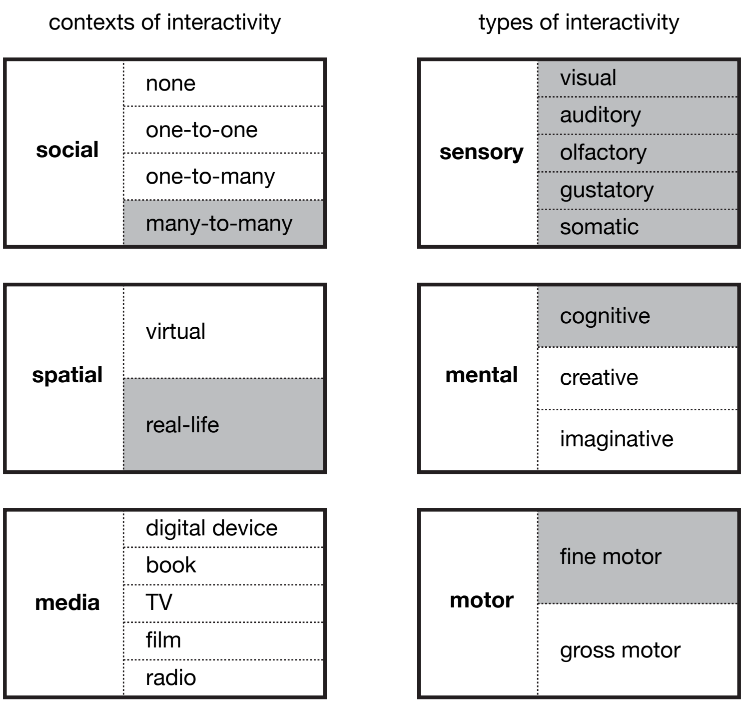


Figure 28: Test of Version 3 on Scenario 1 (Eating a meal with family in real life)

The test of Version 3 on Scenario 1 is shown in Figure 28. The types of interactivity are located in the right-hand column. These include sensory interactivity, mental interactivity, and motor interactivity. All the sensory interactivity types are present in this scenario, so these are shaded accordingly. The only mental interactivity type shaded was cognitive interactivity, since this is required to understand the sensory stimuli. Since nothing is being created or imagined, it is expected that both creative interactivity and imaginative interactivity are not present. Fine motor interactivity is present, but gross motor interactivity is not, as the main motor movement that occurs during a meal is primarily hand-related.

The contexts of interactivity are located in the left-hand column. These include social interactivity, spatial interactivity, and media interactivity. The social interactivity present in this scenario is many-to-many, since eating with other people typically involves conversations occurring simultaneously between several people. The spatial interactivity present is real-life because this scenario is occurring in the real world. There is no media interactivity present because there is no media being used (although, as mentioned, this is likely different in many dining contexts today due to recent changes in the patterns of smartphone use).

Scenario 2: Silent reading of the printed book *The Hundred-Foot Journey*

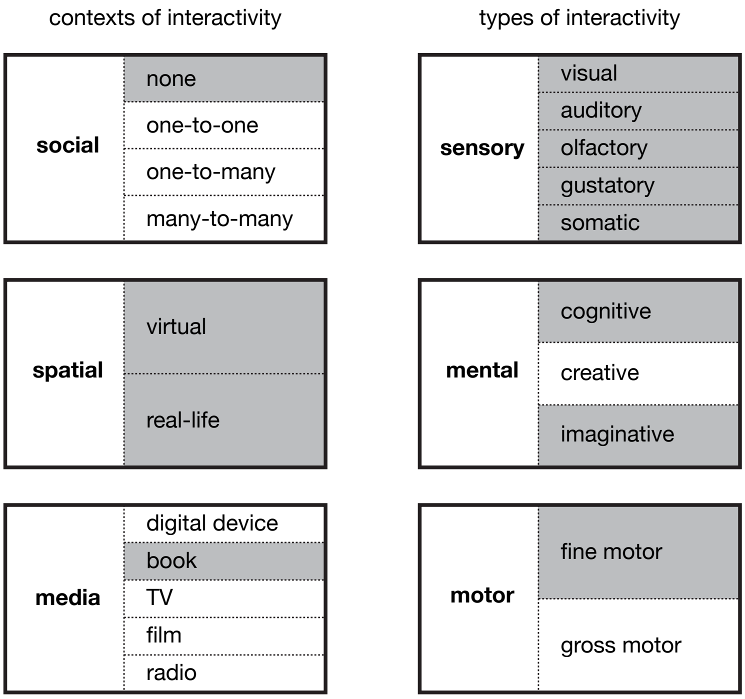


Figure 29: Test of Version 3 on Scenario 2 (Silent reading of the printed book The Hundred-Foot Journey*)*

The test of Version 3 on Scenario 2 is shown in Figure 29. This is largely similar to the Version 2 test on Scenario 2. However, there are a number of differences due to the changes in the layout of the model. Social interactivity now has sub-dimensions and here the 'none' box is shaded since there is no social interactivity (reading is a solo activity). Media interactivity also has sub-dimensions now, and in this instance the book sub-dimension is shaded. Finally, the motor interactivity dimension is also divided into sub-dimensions and the fine motor sub-dimension is shaded because reading a book involves fine motor movement.

Scenario 3: Playing 3-on-3 basketball in real life

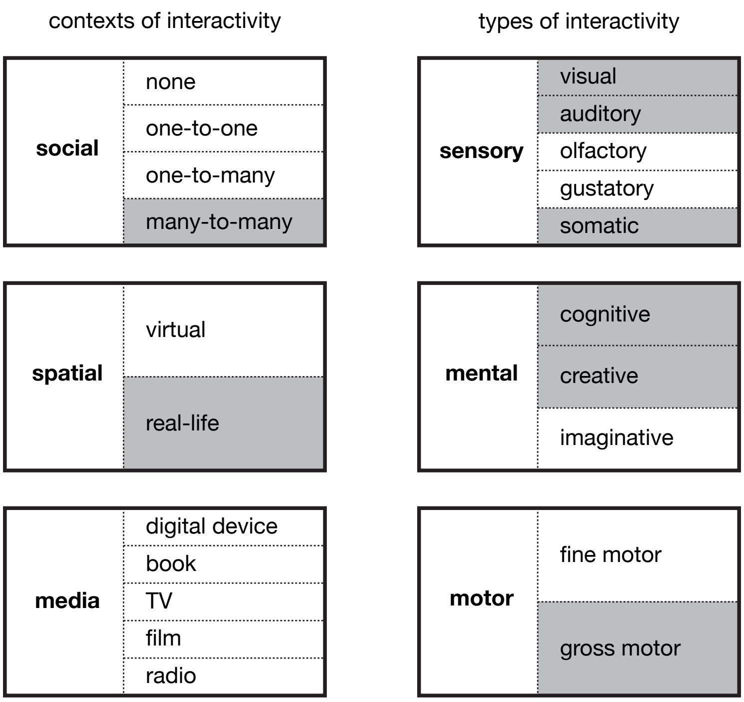


Figure 30: Test of Version 3 on Scenario 3 (Playing 3-on-3 basketball in real life)

The test of Version 3 on Scenario 3 is shown in Figure 30. As with Scenario 2, the test of Version 3 on Scenario 3 is largely similar to the Version 2 test on Scenario 3. The only differences are in the social interactivity, media interactivity, and motor interactivity dimensions, which are now divided into sub-dimensions. Under social interactivity, the many-to-many sub-dimension is shaded since the individual is playing with several other individuals. No media interactivity sub-dimensions are shaded since no media was used. Under motor interactivity, the gross motor sub-dimension is shaded because playing basketball uses gross motor movement.

Scenario 4: Playing 3-on-3 basketball in the *Wii Sports Resort* game

The test of Version 3 on Scenario 4 is shown in Figure 31. This is similar to the test of Version 2 on Scenario 4. As in Scenario 3 above, the only differences between Version 2 and Version 3 tests are in the social interactivity, media interactivity, and motor interactivity dimensions. Under social interactivity, the one-to-one sub-dimension is shaded since the individual is playing with only one other player (the game does not allow for more than two players). Under media interactivity, the digital device sub-dimension is shaded since a Nintendo Wii console is being used. Under motor interactivity, the fine motor and gross motor sub-dimensions are shaded since both fine motor and gross motor movements are required to use the Wii game controller.

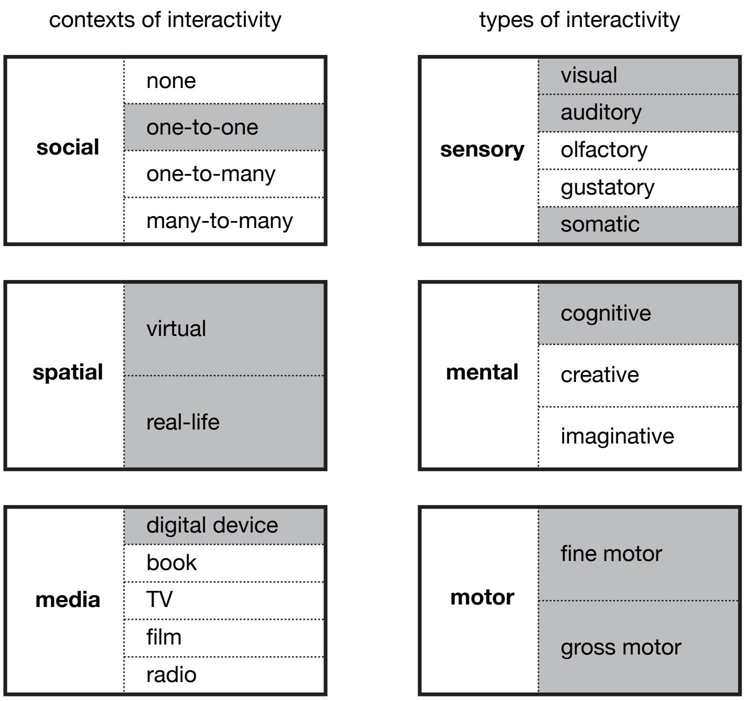


Figure 31: Test of Version 3 on Scenario 4 (Playing 3-on-3 basketball in the Wii Sports Resort *game)*

Scenario 5: Playing the *Driveclub VR* game using the Playstation VR and Playstation 4

The test of Version 3 on Scenario 5 is shown in Figure 32. The 'none' box is shaded as there is no social interactivity, since the game has no capacity for multiple players as yet. Spatial interactivity is both virtual and real-life because the player interacts in both virtual and real-life spaces. Motor interactivity is both fine motor and gross motor as the game controller requires the use of both finger movements (fine motor) and whole arm movements (gross motor). The media interactivity sub-dimension is digital device. All these aforementioned sub-dimensions are shaded. Interestingly, the same sensory interactivity and mental interactivity sub-dimensions are present in both Scenario 4 and Scenario 5.

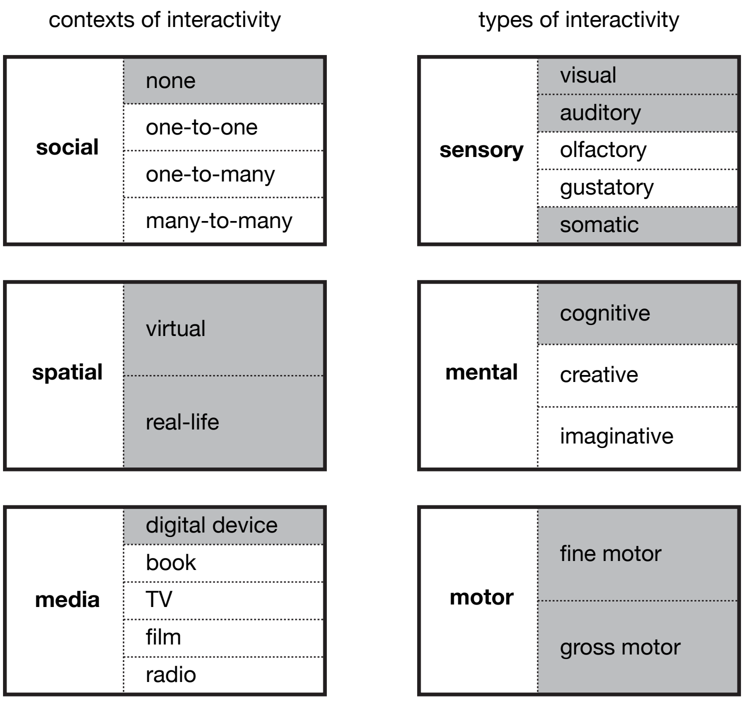


Figure 32: Test of Version 3 on Scenario 5 (Playing the Driveclub VR *game using the Playstation VR and Playstation 4)*

Evaluation of Version 3

Two main observations were made about Version 3. First, it seemed counter-intuitive to have a 'none' box under social interactivity. Having a shaded 'none' box is visually confusing as it seems to suggest that there is a social interactivity sub-dimension present. Thus, if social interactivity is absent, it makes more sense to have no sub-dimensions or dimensions shaded instead. Second, the tests on Scenario 4 and Scenario 5 seemed to suggest that the interactivity in these is similar, even though one is a virtual reality video game and one is non-virtual reality video game. This is odd, given that the interactivity aesthetics in each of these feels different even when the differences in social interactivity are taken into account. From this, it is hypothesised that the relationships between the interactivity dimensions and sub-dimensions is central to visually articulating the differences between experiences, particularly between virtual reality and non-virtual reality ones.

Changes recommended for Version 4

Three main changes are proposed here. First, it is proposed that the use of shading to indicate the presence of a dimension and/or sub-dimension be continued. Additionally, where a dimension or sub-dimension is absent, the assigned box is left unshaded and there will be no ‘none’ boxes used. Second, the sub-dimensions listed under media interactivity is not an exhaustive list and could change over time. To future-proof this dimension and make it less complex, it is proposed that the sub-dimensions be reduced to two: digital and non-digital. Third, the structure of the model in Version 3 needs to be adjusted in order to show the relationships between sub-dimensions across different dimensions. This comes after having established that the relationships between the different sub-dimensions and dimensions of interactivity is of key importance.

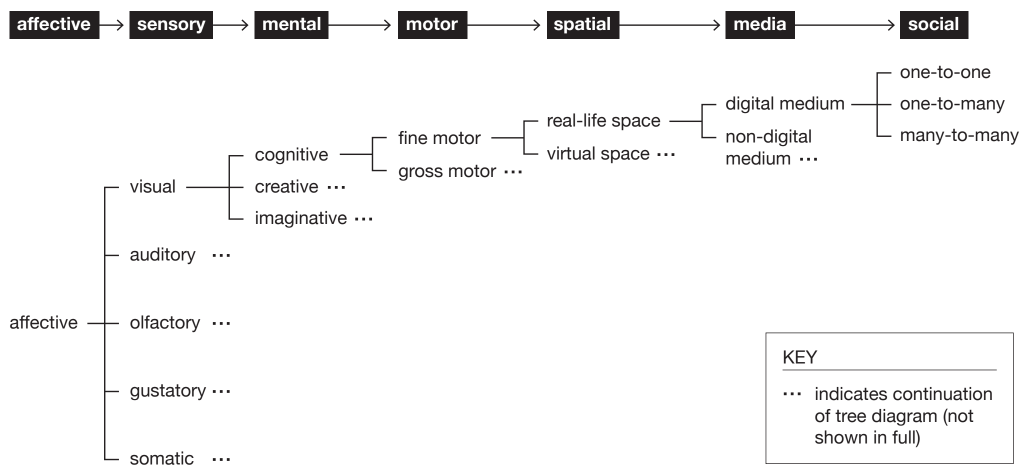


Figure 33: Tree diagram showing relationships between interactivity sub-dimensions

To achieve the last change proposed above, a period of brainstorming followed. A tree diagram was developed to try and illustrate these relationships (see Figure 33). Affective interactivity was placed at the start because “emotion drives attention, which drives learning, memory, and problem-solving behavior [sic]” (Weiss 2000, 46); emotions (or affects) are our response to external stimuli. The explanation for the remaining order of placement is as follows: we interact with external stimuli using various sensory modes; in turn, sensory input results in mental activity and can also generate an affective response, so it makes sense to have sensory interactivity between affective interactivity and mental interactivity; motor interactivity follows next because it results from mental interactivity; after this comes spatial interactivity because movement typically occurs in a space; then media interactivity because media use can occur in both real-life and virtual spaces; social interactivity is last because, in terms of physical proximity, other people are generally located furthest from the person having the experience.

The problem with using a tree diagram format was that if every branch were to be depicted, the model would be too visually complex to be easily interpreted. The discovery of the thought-movement-perception cycle (see Figure 6 on page 147), with emotion at the centre, led to the conception of a circular model. A circular model seemed ideal because it could allow for the various relationships between individual interactivity sub-dimensions to be depicted—the relationship between interactivity sub-dimensions within the same dimension, and the relationship between interactivity sub-dimensions across dimensions. To clarify whether the concept of a circular model would be suitable, additional research was conducted into other related circular models in the process of developing Version 4 (see page 153).

Model of interactivity—Version 4

In the process of developing Version 4, different geometric shapes (e.g. triangles and other polygons) were experimented with in order to find a more effective method of visual representation. One of the attempts used a circular format, which eventually resulted in Version 4. Three views of Version 4 are included here to facilitate its explanation. The first view (Figure 34) shows the interactivity dimensions, organised as concentric rings, where each ring represents a dimension. The order of the rings (from inside to out) attempted to represent the location of the interactivity dimension in relation to the individual user/learner (those internal to versus those external to the user/learner) as well as the order of influence (i.e. affect is at the

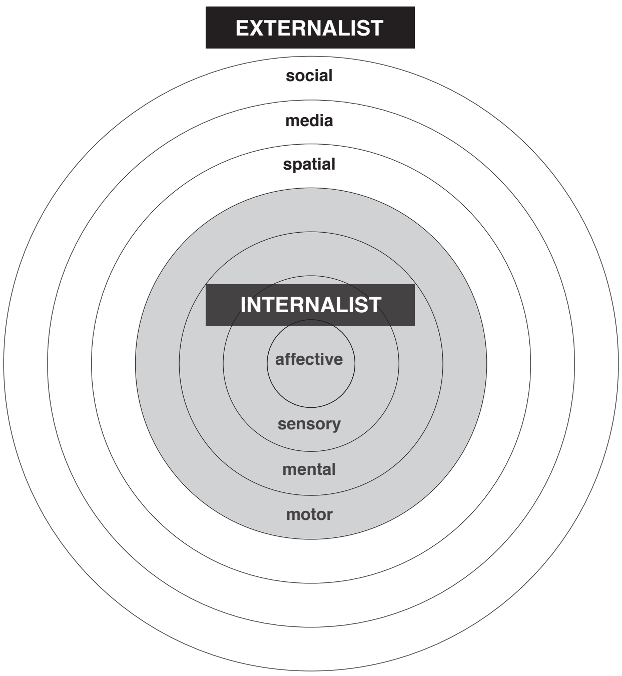


Figure 34: Internalist and externalist dimensions of interactivity

centre of all interactivity; sensory perception is influenced by—and influences—affect; mental activity is influenced by—and influences—sensory perception; motor activity is influenced by mental activity).

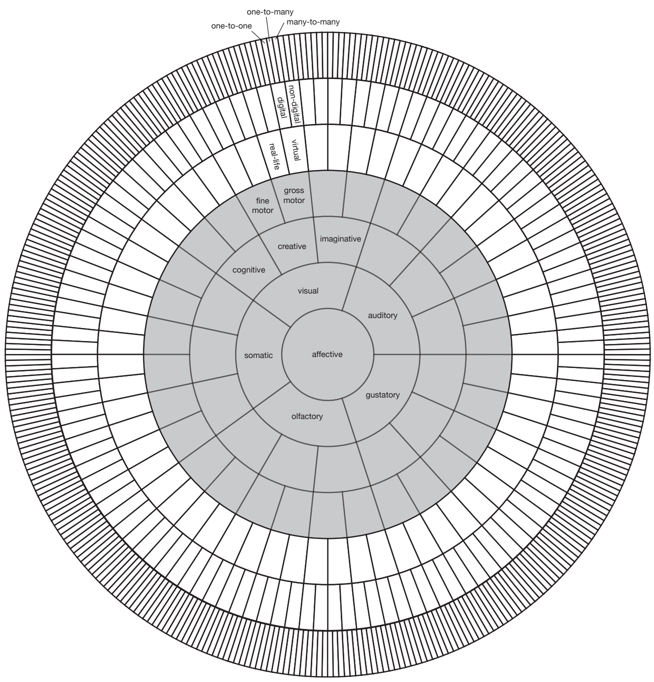


Figure 35: Model of interactivity—Version 4

The second view (Figure 35) shows how the sub-dimensions were organised in Version 4. For each dimension, the corresponding ring was divided into segments, with each segment representing an interactivity sub-dimension (i.e. the sensory dimension ring was divided into five segments: visual, auditory, olfactory, gustatory, and somatic). For each different interactivity sub-dimension, the sub-dimensions in the adjacent dimension were repeated around the ring (i.e. the cognitive, creative, and imaginative interactivity sub-dimensions were repeated for each sensory interactivity sub-dimension, and so on).

The third view shows how the presence of the different sub-dimensions is indicated—Figure 36 shows what Version 4 of the model would look like if all interactivity sub-dimensions are present. Here, colour was introduced to make it easier to read the model at a glance. Red was assigned to the affective dimension, and a different colour was assigned to each of the five sensory sub-dimensions (visual: yellow; auditory: orange; gustatory: green; olfactory: purple; somatic: blue). If an interactivity sub-dimension was absent, the corresponding segment was shaded in a light grey. For each interactivity sub-dimension that was present, the corresponding

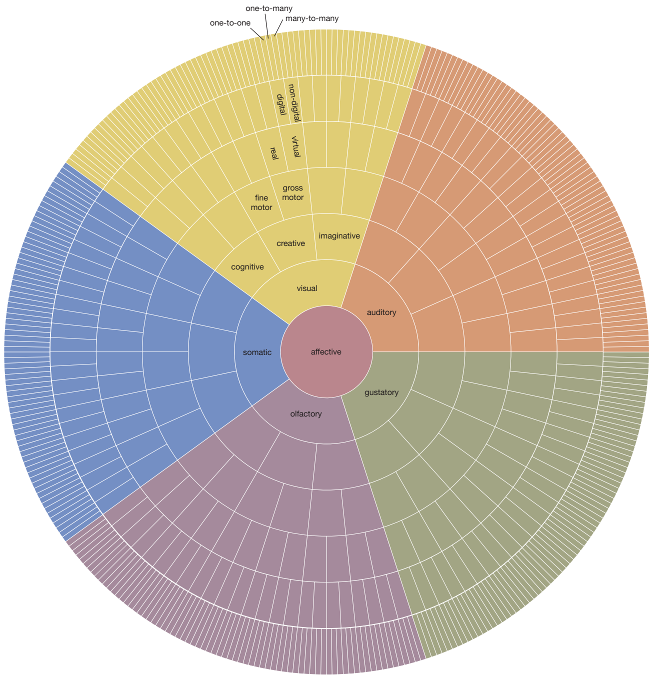


Figure 36: Model of interactivity—Version 4 (colour)

segment was filled in with the colour assigned to the sensory sub-dimension it related to.

During testing, three main issues were identified with Version 4. The first issue related to the visual complexity of the model. The plethora of segments in Version 4 made it difficult to remember which segments were assigned to which dimensions or sub-dimensions. Also, the demarcation between the different sensory interactivity sub-dimensions was not distinct enough. The second issue related to the affective dimension. It was observed that dividing the affective dimension into sub-dimensions would make the model too complex. Furthermore, since the affective dimension was always coloured (this was based on the assumption that all interactivity is the result of affect or results in an affective response), it was not necessary to include it in the model. The third issue was that a temporal dimension was needed to differentiate between synchronous and asynchronous interactivity.

Model of interactivity—Version 4 testing

Version 4 of the model of interactivity was successfully tested on all the scenarios—Scenarios 1 to 9. A circular model was used in Version 4. The model consists of rings and each ring is divided into segments. The interactivity dimensions are not separate stand-alone segments. Instead, they are used to label the rings which contain the interactivity sub-dimension segments. The segments of the interactivity sub-dimensions that are present are shaded in colour; those that are absent are left uncoloured in a light grey.

The results of the Version 4 testing are described below. For each scenario, this starts with a short overview of the results and is followed by an explanation of each of the shaded sub-dimension segments. Due to the complexity of the model and for purposes of clarity, these explanations are presented in a table format, with each sensory sub-dimension is presented as a separate table.

Scenario 1: Eating with family in real life

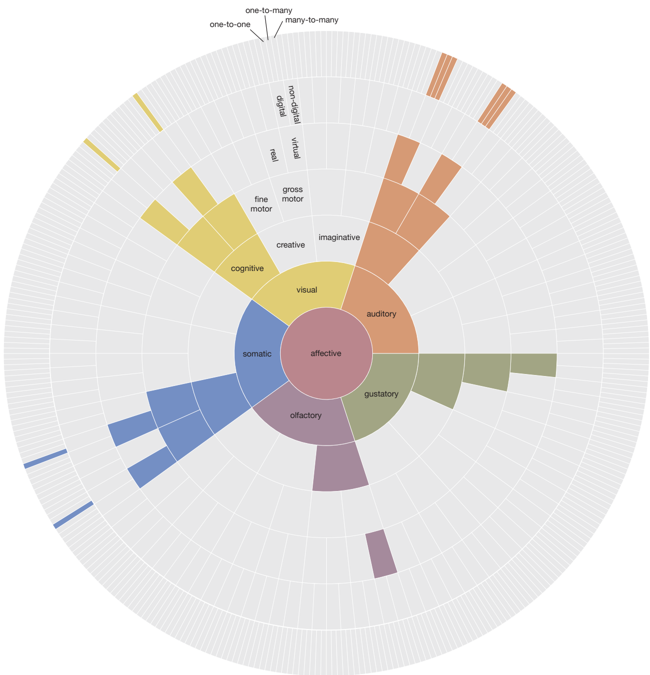


Figure 37: Test of Version 4 on Scenario 1 (Eating with family in real life)

The structure of Version 4 allowed the relationships between the sensory interactivity sub-dimensions and the other interactivity sub-dimensions to be illustrated. Figure 37 shows the different interactivity sub-dimensions present in Scenario 1. A different colour was assigned to each sensory interactivity sub-dimension and these colours were used to visually indicate the sub-dimensions of the other interactivity dimensions that related to each sensory interactivity sub-dimension. The use of colour in this manner resulted a colourful model resembling a mandala.

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Cognitive (i.e. used to perceive visual information, such as food, people, etc.)	Fine motor (i.e. using cutlery)	Real (i.e. occurring in the real world)	None	Many-to-many (i.e. seeing everyone at once)
		Gross motor (i.e. standing and reaching for food)	Real (i.e. occurring in the real world)	None	Many-to-many (i.e. seeing everyone at once)

Sensory	Mental	Motor	Spatial	Media	Social
Auditory	Cognitive (e.g. used to perceive sound, such as what other people are saying)	Fine motor (i.e. hearing the sound of the knife cutting through meat)	Real (i.e. occurring in the real world)	None	One-to-one
					One-to-many
					Many-to-many (differs based on type of conversation)
		Gross motor (e.g. movement responding to someone saying, "Pass the salt")	Real (i.e. occurring in the real world)	None	One-to-one
					One-to-many
					Many-to-many (differs based on type of conversation)

Sensory	Mental	Motor	Spatial	Media	Social
Gustatory	Cognitive (i.e. used to perceive taste)	Fine motor (i.e. chewing)	Real (i.e. occurring in the real world)	None	No social interaction involving taste

Sensory	Mental	Motor	Spatial	Media	Social
Olfactory	Cognitive (i.e. used to perceive smell)	None (no conscious movement involved in smelling)	Real (i.e. occurring in the real world)	None	No social interaction involving smell

Sensory	Mental	Motor	Spatial	Media	Social
Somatic	Cognitive (i.e. used to perceive touch-based sensory information)	Fine motor (i.e. holding and moving cutlery or food)	Real (i.e. occurring in the real world)	None	One-to-one (e.g. brushing against the hand of the person next to you)
		Gross motor (e.g. passing food to someone)	Real (i.e. occurring in the real world)	None	One-to-one (e.g. accidentally knocking into the person next to you)

If the function of the model is to map perceived interactivity, then Figure 37 shows only one possible outcome. An alternative model, where the individual's experience of the meal also involves imaginative interactivity (i.e. the individual imagining the sight, smell, and taste of a previous meal experience in comparison to the current real-life meal), is shown in Figure 38.

Figure 38: Test of final model on Scenario 1 (alternative result)

Scenario 2: Silent reading of the printed book *The Hundred-Foot Journey*

The test of Version 4 on Scenario 2 is shown in Figure 39. Contrary to what some might expect, this scenario involved a large variety of interactivity, due to the fact that it involved all the sensory modes, even though much of this was imagined rather than occurring in real life.

This supports Walter's (2013) argument that reading is a form of interactive media and explains why respondents in Ermi and Mäyrä's (2007) research described reading as being emotionally immersive.

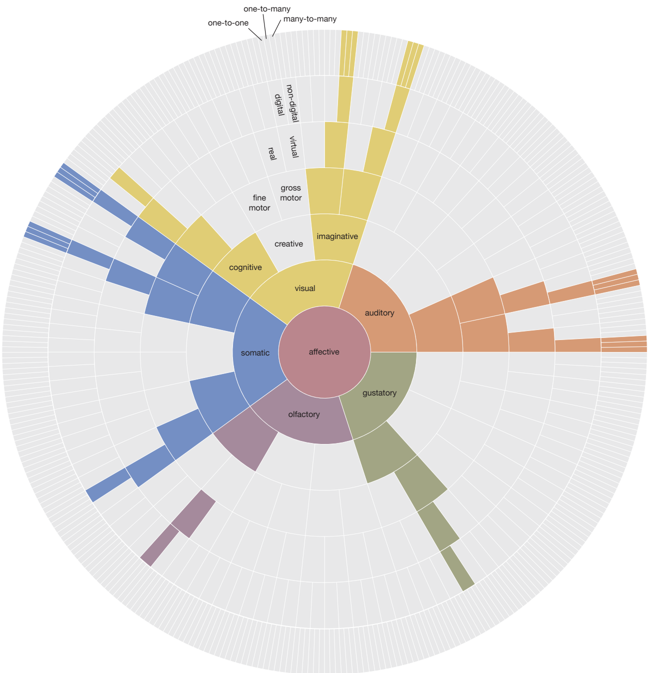


Figure 39: Test of Version 4 on Scenario 2 (Silent reading of the printed book The Hundred-Foot Journey*)*

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Cognitive (i.e. reading the text in the book)	Fine motor (i.e. turning the pages to read the text)	Real (i.e. occurring in real-life)	Non-digital (i.e. books are a non-digital medium)	Book is read alone
	Imaginative (i.e. imagining the visuals from reading the text)	Fine motor (i.e. imagining fine motor movements performed by book characters)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	One-to-one
					One-to-many
					Many-to-many (all social interactions are imagined)
		Gross motor (i.e. imagining gross motor movements performed by book characters)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	One-to-one
					One-to-many
					Many-to-many (all social interactions are imagined)

Sensory	Mental	Motor	Spatial	Media	Social
Auditory	Imaginative (e.g. used to imagine sound of characters talking, ambient noises, etc.)	Fine motor (i.e. imagining sounds relating to fine motor movement)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	One-to-one
					One-to-many
					Many-to-many (differs based on type of conversation)
		Gross motor (i.e. imagining sounds relating to gross motor movement)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	One-to-one
					One-to-many
					Many-to-many (differs based on type of conversation)

Sensory	Mental	Motor	Spatial	Media	Social
Olfactory	Imaginative (e.g. imagining the smell of food)	None (no conscious movement involved in smelling)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	No social interaction involving smell

Sensory	Mental	Motor	Spatial	Media	Social
Somatic	Cognitive (i.e. touching the pages of the book)	Fine motor (i.e. turning the pages)	Real (i.e. occurring in real-life)	Non-digital (i.e. books are a non-digital medium)	Book is read alone
	Imaginative (i.e. imagining what it feels like to touch objects or people in the book)	Fine motor (i.e. imagining fine motor movements performed by book characters)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	One-to-one
					One-to-many
					Many-to-many (all social interactions are imagined)
		Gross motor (i.e. imagining gross motor movements performed by book characters)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	One-to-one
					One-to-many
					Many-to-many (all social interactions are imagined)

Sensory	Mental	Motor	Spatial	Media	Social
Gustatory	Imaginative (e.g. imagining the taste of food)	Fine motor (i.e. chewing)	Virtual (i.e. imagined and therefore not occurring in the real world)	Non-digital (i.e. books are a non-digital medium)	No social interaction involving taste

Scenario 3: Playing 3-on-3 basketball in real life

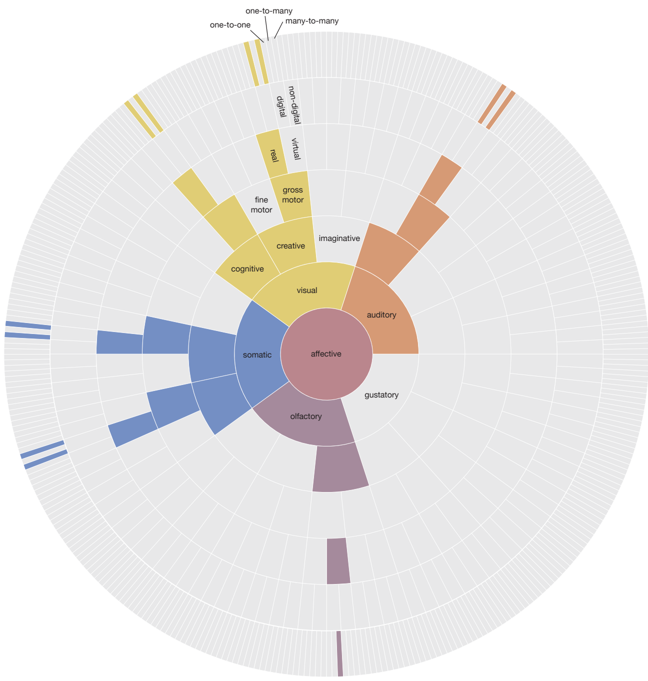


Figure 40: Test of Version 4 on Scenario 3 (Playing 3-on-3 basketball in real life)

As seen in Figure 40, Scenario 3 is less interactive than Scenario 2. In Scenario 3, there is no gustatory interactivity and olfactory interactivity occurs primarily in relation to the smell of perspiration and other body odours, and to a lesser extent the smell of the basketball and the court environment. The movement is primarily gross motor-based and no media is used.

Sensory	Mental	Motor	Spatial	Media	Social
Olfactory	Cognitive (e.g. used to perceive smell, such as perspiration)	None	Real (i.e. occurring in real-life)	None	One-to-one (i.e. the smell of the other player)

Sensory	Mental	Motor	Spatial	Media	Social
Auditory	Cognitive (e.g. used to perceive sound)	Gross motor (i.e. running, dribbling the ball)	Real (i.e. occurring in real-life)	None	One-to-one (i.e. players match up against one player)
					Many-to-many (i.e. have to listen out for all players at the same time)

Sensory	Mental	Motor	Spatial	Media	Social
Somatic	Cognitive (i.e. used to perceive touch-based information)	Gross motor (i.e. running, dribbling the ball)	Real (i.e. occurring in real-life)	None	One-to-one (i.e. physical contact with one player)
					Many-to-many (i.e. physical contact with more than one player at the same time)
	Creative (i.e. trying to figure out how to get past defence)	Gross motor (i.e. running, dribbling the ball)	Real (i.e. occurring in real-life)	None	One-to-one (i.e. physical contact with one player)
					Many-to-many (i.e. physical contact with more than one player at the same time)

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Cognitive (i.e. used to perceive visual information)	Gross motor (i.e. running, dribbling the ball)	Real (i.e. occurring in real-life)	None	One-to-one (i.e. players match up against one player)
					Many-to-many (i.e. have to visually watch all players at the same time)
	Creative (i.e. trying to figure out how to get past defence)	Gross motor (i.e. running, dribbling the ball)	Real (i.e. occurring in real-life)	None	One-to-one (i.e. players match up against one player)
					Many-to-many (i.e. have to visually watch all players at the same time)

Scenario 4: Playing 3-on-3 basketball in the *Wii Sports Resort* game

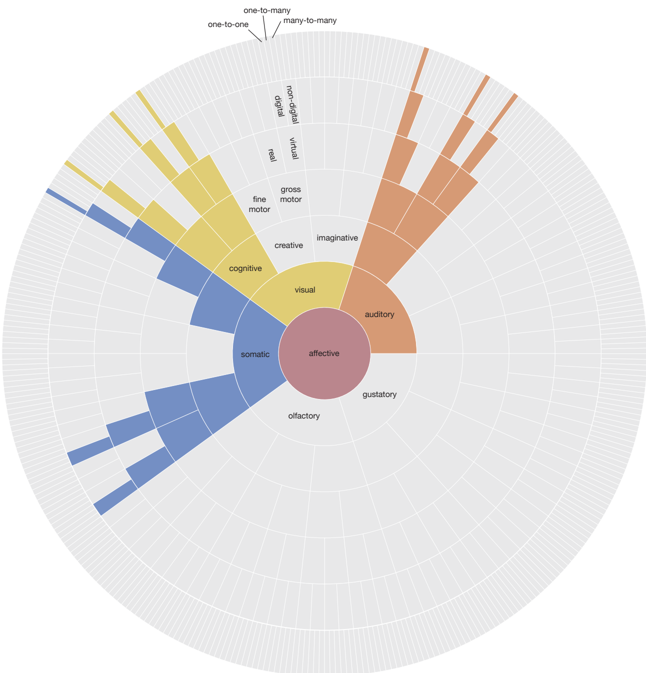


Figure 41: Test of Version 4 on Scenario 4 (Playing 3-on-3 basketball in the Wii Sports Resort *game)*

The test of Version 4 on Scenario 4 is shown in Figure 41. Scenario 4 has less variety of sensory interactivity than Scenario 3; it has no olfactory or gustatory interactivity. Unlike Scenario 3, this scenario involves the use of media (a Nintendo Wii game console and Wii game controllers). It also uses different mental interactivity from Scenario 3—mainly cognitive and imaginative, and no creative interactivity.

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Cognitive (i.e. used to perceive visual information)	Fine motor (i.e. pressing the buttons on the controller in response to what is seen)	Real (i.e. occurring in real-life)	Digital (i.e. pressing buttons on the game controller)	One-to-one (i.e. seeing the other real-life player)
		Gross motor (i.e. moving the controller in response to what is seen)	Real (i.e. occurring in real-life)	Digital (i.e. waving the game controller)	One-to-one (i.e. seeing the other real-life player)
			Virtual (i.e. imagined, not occurring in the real world)	Digital (i.e. using the game controller to control virtual movement)	One-to-one (i.e. can only play against one other virtual player at a time)

Sensory	Mental	Motor	Spatial	Media	Social
Auditory	Cognitive (i.e. used to perceive sound)	Fine motor (i.e. sounds relating to using fingers to pressing the buttons)	Real (i.e. the sound of the controller buttons being pressed)	Digital (i.e. pressing buttons on Nintendo Wii game controller)	One-to-one (i.e. hearing the sounds of the other real-life player)
		Gross motor (i.e. sounds related to moving the controller around using hand and arm)	Real (i.e. sounds relating to real-world movement)	Digital (i.e. waving the Nintendo Wii game controller around)	One-to-one (i.e. hearing the sounds of the other real-life player)
			Virtual (i.e. sounds from within the game)	Digital (i.e. using Nintendo Wii game controller to control virtual movement)	One-to-one (i.e. hearing the sounds of the virtual players in the game)

Sensory	Mental	Motor	Spatial	Media	Social
Somatic	Cognitive (i.e. used to perceive touch-based information)	Fine motor (i.e. the feel of the controller buttons)	Real (i.e. occurring in real-life)	Digital (i.e. using Nintendo Wii game controller)	None
		Gross motor (i.e. the feel of the controller in the hand during movement)	Real (i.e. occurring in real-life)	Digital (i.e. holding and waving Nintendo Wii game controller)	None
	Imaginative (i.e. used to imagine touch)	Gross motor (i.e. pushing or blocking another player in the game)	Virtual (i.e. dribbling the ball, pushing against players, etc.)	Digital (i.e. using the movement Nintendo Wii game controller to mimic the movement in the game)	One-to-one (i.e. playing against one other virtual player)

Scenario 5: Playing the *Driveclub VR* game using the Playstation VR and Playstation 4

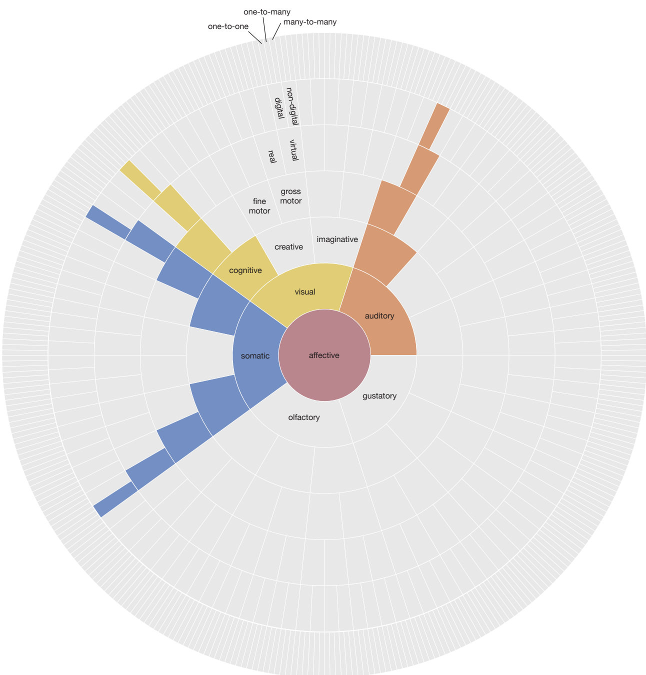


Figure 42: Test of Version 4 on Scenario 5 (Playing the Driveclub VR *game using the Playstation VR and Playstation 4)*

The test of Version 4 on Scenario 5—playing the *Driveclub VR* game using the Playstation VR and Playstation 4—is shown in Figure 42. Virtual reality headsets such as the Playstation VR and the Oculus Rift have only been around for a short time, and the technology is relatively new. As such, in some ways it is less advanced than more established gaming-related technologies. In the *Driveclub VR* game, for example, social interactivity is non-existent—possibly because the present-day average hardware is as yet unable to cope with processing the volume of information required for a multi-player virtual reality driving game. Interestingly, in this scenario both the visual and auditory interactivity are different from Scenario 4 (which requires the use of the Nintendo Wii game console). With the Wii game console, the player has both real-life and virtual visual and auditory interactivity (i.e. the player sees and hears both in real-life and in the virtual world of the game). With virtual reality, however, there is no real-life visual or auditory interactivity; these are supplanted by the visual and auditory information from the virtual reality headset.

Sensory	**Mental**	**Motor**	**Spatial**	**Media**	**Social**
Visual	Cognitive (i.e. used to perceive visual information)	Fine motor (i.e. pressing the buttons on the controller in response to what is seen)	Virtual (i.e. visuals are of a virtual space)	Digital (i.e. visuals are of the virtual world in game)	None

Sensory	**Mental**	**Motor**	**Spatial**	**Media**	**Social**
Auditory	Cognitive (i.e. used to perceive sound from game)	Fine motor (i.e. using fingers to press the buttons based on sounds heard)	Virtual (i.e. sounds relate to a virtual space)	Digital (i.e. sounds are from game console)	None

Sensory	**Mental**	**Motor**	**Spatial**	**Media**	**Social**
Somatic	Cognitive (i.e. used to perceive touch-based information)	Fine motor (i.e. the feel of the controller buttons)	Real (i.e. touch the controller in real-life)	Digital (i.e. using game controller)	None
	Imaginative (i.e. used to imagine touch)	Gross motor (i.e. turning the steering wheel)	Virtual (i.e. touching the steering wheel in a virtual car)	Digital (i.e. imagining the texture of steering wheel and the seat)	None

Scenario 6: Driving in a dream

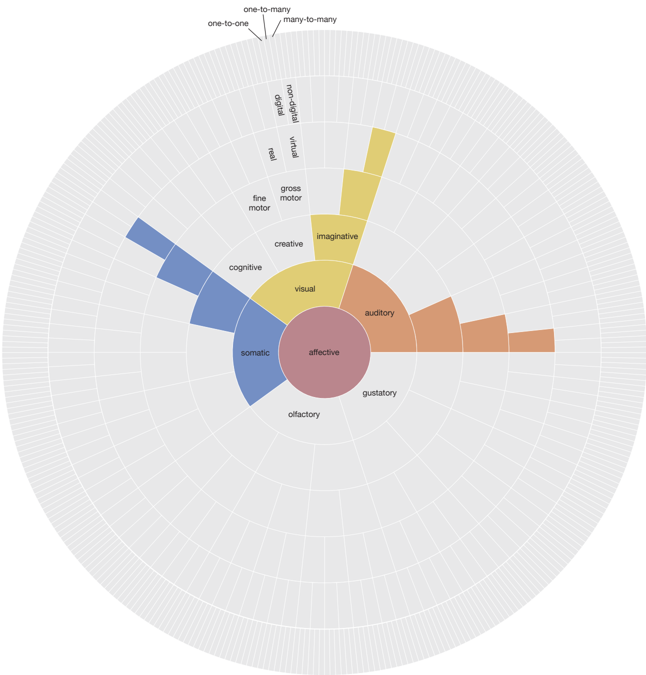


Figure 43: Test of Version 4 on Scenario 6 (Driving in a dream)

The test of Version 4 on Scenario 6—driving in a dream—is shown in Figure 43. As mentioned in "Scenario 6: Driving in a dream" on page 174, this test was a predictive one and was based on my perspective as an average person who has all of the five sensory functions (visual, auditory, gustatory, olfactory, and somatic). Additionally, taking into account the research examined in "Scenario 6: Driving in a dream", it was assumed that only visual, auditory, and somatic interactivity were present and no olfactory or gustatory interactivity was present, since this is statistically unlikely based on the findings of Schwartz and Maquet (2002) and Zadra, Nielsen and Donderi (1998).

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Imaginative (i.e. used to imagine visuals in the dream)	Gross motor (i.e. turning the steering wheel in response to what is seen)	Virtual (i.e. occurring during in a dream, not in real life)	None	None

Sensory	**Mental**	**Motor**	**Spatial**	**Media**	**Social**
Auditory	Imaginative (i.e. used to imagine the sound in the dream)	Gross motor (i.e. turning the steering wheel based on sounds heard)	Virtual (i.e. occurring during in a dream, not in real life)	None	None

Sensory	**Mental**	**Motor**	**Spatial**	**Media**	**Social**
Somatic	Imaginative (i.e. used to imagine touching objects in the dream)	Gross motor (e.g. the feel of holding and turning the steering wheel)	Virtual (i.e. occurring during in a dream, not in real life)	None	None

Scenario 7: Playing Beethoven's *Für Elise* on the piano while referring to printed sheet music

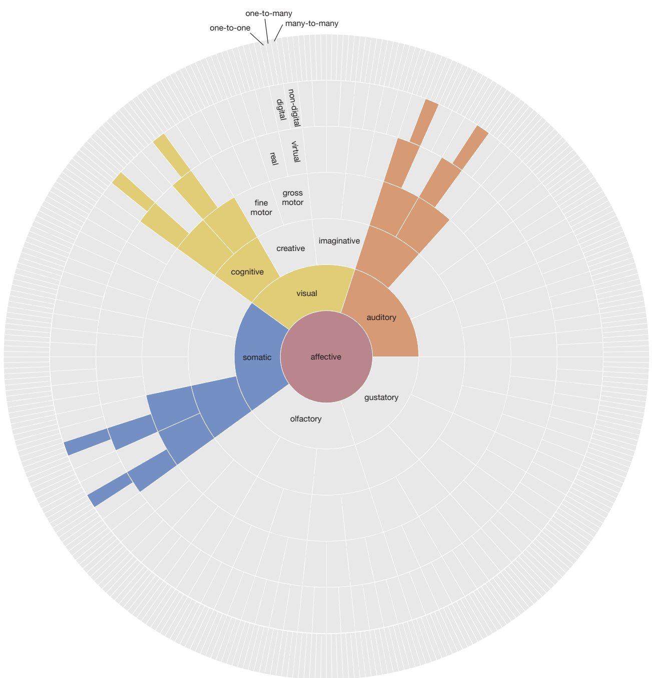


Figure 44: Test of Version 4 on Scenario 7 (Playing Beethoven's Für Elise *on the piano while referring to printed sheet music)*

The test of Version 4 on Scenario 7 is shown in Figure 44. As Figure 44 shows, the sensory interactivity present here is limited to the visual, auditory, and somatic. The mental interactivity is mainly cognitive as it involves 'reading' the music score. (However, if the scenario was about composing music then creative interactivity would also be present.) The motor interactivity is fine motor, the spatial interactivity is real, and the media interactivity is non-digital. Since it is assumed here that the pianist is not playing to an audience, there is no social interactivity present. This would be different in a concert scenario; in a concert scenario, the social interactivity would be one-to-many.

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Cognitive (i.e. used to perceive visual information)	Fine motor (i.e. moving fingers in line with what is seen in the music score)	Real (i.e. occurring in real-life)	Non-digital (i.e. printed medium is used here)	None
		Gross motor (i.e. moving arms and feet in line with what is seen in the music score)	Real (i.e. occurring in real-life)	Non-digital (i.e. printed medium is used here)	None

Sensory	Mental	Motor	Spatial	Media	Social
Auditory	Cognitive (i.e. used to perceive sound)	Fine motor (i.e. moving fingers in line with what is heard)	Real (i.e. occurring in real-life)	Non-digital (i.e. printed medium is used here)	None
		Gross motor (i.e. moving arms and feet in line with what is heard)	Real (i.e. occurring in real-life)	Non-digital (i.e. printed medium is used here)	None

Sensory	Mental	Motor	Spatial	Media	Social
Somatic	Cognitive (i.e. used to perceive touch-based information)	Fine motor (i.e. moving fingers and feeling the piano keys)	Real (i.e. occurring in real-life)	Non-digital (i.e. printed medium is used here)	None
		Gross motor (i.e. moving arms and feet and feeling the piano keys and pedals)	Real (i.e. occurring in real-life)	Non-digital (i.e. printed medium is used here)	None

Scenario 8: Painting using Photoshop on a Macbook Air

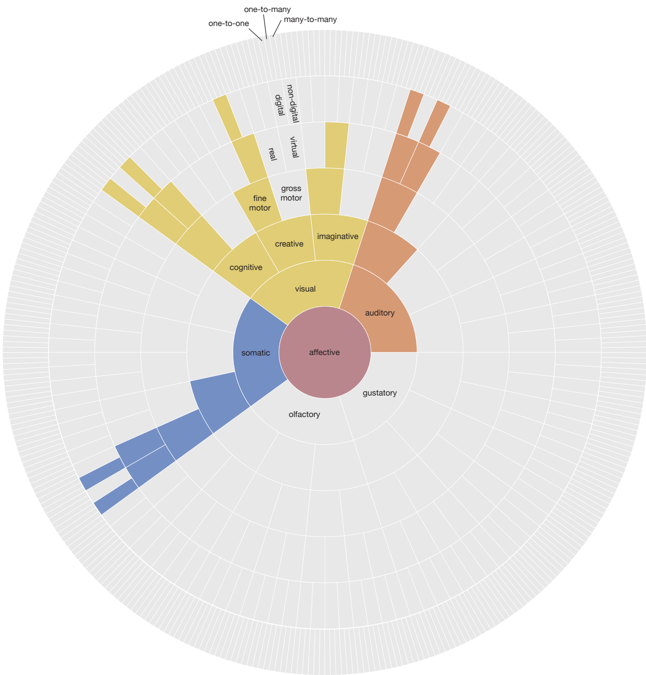


Figure 45: Test of Version 4 on Scenario 8 (Painting using Photoshop on a Macbook Air)

The test of Version 4 on Scenario 8 is shown in Figure 45. The sensory interactivity sub-dimensions present are visual and somatic. All three mental interactivity sub-dimensions are present with regard to visual interactivity, but only cognitive interactivity is present with regard to somatic interactivity (e.g. touching the touchpad or keyboard) and auditory interactivity.

Sensory	Mental	Motor	Spatial	Media	Social
Auditory	Cognitive (i.e. used to perceive sound of keyboard and computer alerts)	Fine motor (i.e. moving fingers and hand to use the touchpad and keyboard)	Real (e.g. real-life sounds of keyboard buttons being pressed)	Digital (i.e. computer laptop is used)	None
			Virtual (e.g. sounds from the software)	Digital (i.e. computer laptop is used)	None

Sensory	Mental	Motor	Spatial	Media	Social
Somatic	Cognitive (i.e. used to perceive touch-based information)	Fine motor (e.g. pressing keyboard buttons with fingers)	Real (e.g. touching the keyboard buttons in real life)	Digital (i.e. computer laptop is used)	None
			Virtual (e.g. touching icons in the software using the mouse arrow)	Digital (i.e. computer laptop is used)	None

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Cognitive (i.e. used to perceive visual information)	Fine motor (i.e. moving fingers in line with what is seen on screen)	Real (i.e. looking at the keyboard, physical computer screen)	Digital (i.e. computer laptop is used)	None
			Virtual (i.e. looking at the images in Photoshop on screen)	Digital (i.e. computer laptop is used)	None
	Creative	Fine motor (e.g. creative production of visuals using fine motor movement)	Virtual (i.e. creative production of images is happening in a virtual space)	Digital (i.e. computer laptop is used)	None
	Imaginative	Fine motor (e.g. imagining visuals while using fine motor movement)	Virtual (i.e. imagining visuals and using them to produce visuals in a virtual space)	None	None

Scenario 9: Texting with friends via an iPhone

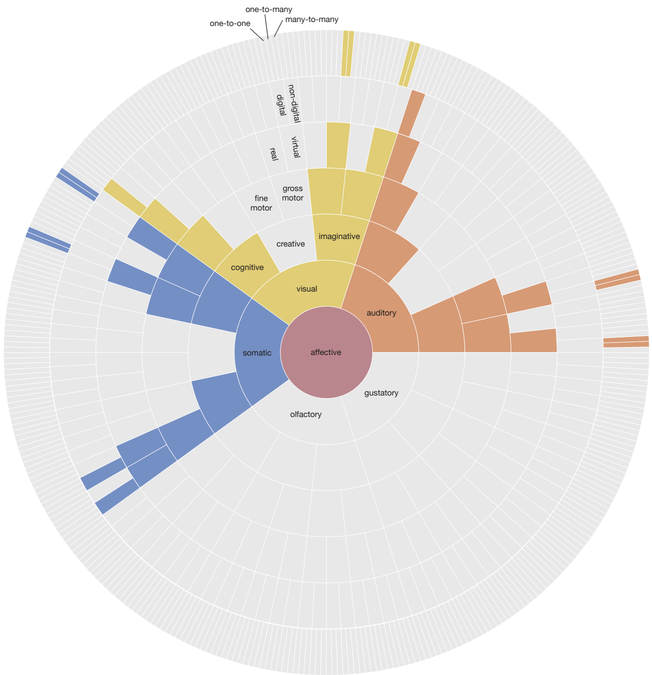


Figure 46: Test of Version 4 on Scenario 9 (Texting with friends via an iPhone)

The test of Version 4 on Scenario 9 is shown in Figure 46. This scenario has three sensory interactivity sub-dimensions present: visual, auditory, and somatic. The mental interactivity sub-dimensions present in relation to these sensory interactivity sub-dimensions are both cognitive (i.e. brain activity required to process real-life activity) and imaginative (i.e. to imagine things that may be described in the text messages). The cognitive-related interactivity sub-dimensions occur in real life, while the imaginative-related interactivity sub-dimensions do not, so spatial interactivity is real for the former, but virtual for the latter. Similarly, the media interactivity relating to the cognitive interactivity is digital, but there is no media interactivity involved in the imaginative interactivity as it happens in the mind. Social interactivity is all imagined in the mind rather than a mediated virtual space. It can be both one-to-one (i.e. messaging between two people) and one-to-many (i.e. one person messaging several others simultaneously).

Sensory	Mental	Motor	Spatial	Media	Social
Auditory	Cognitive (i.e. used to perceive sound of the iPhone)	Fine motor (i.e. moving fingers to press the iPhone screen buttons)	Real (e.g. real-life sounds from using phyiscal iPhone)	Digital (i.e. iPhone)	None
			Virtual (e.g. sounds from the iPhone Messages app)	Digital (i.e. iPhone)	None
	Imaginative (i.e. used to imagine sounds)	Fine motor (i.e. imagining the sounds relating to the fine motor movement)	Virtual (e.g. imagined sounds of of the message recipients)	None	One-to-one
					One-to-many
		Gross motor (i.e. imagining the sounds relating to the gross motor movement)	Virtual (e.g. imagined sounds of of the message recipients)	None	One-to-one
					One-to-many

Sensory	Mental	Motor	Spatial	Media	Social
Somatic	Cognitive (i.e. used to perceive touch-based information)	Fine motor (e.g. pressing the iPhone screen with fingers)	Real (e.g. touching the keyboard buttons in real life)	Digital (i.e. iPhone)	None
			Virtual (e.g. virtually touching app icons)	Digital (i.e. iPhone)	None
	Imaginative (i.e. imagining touching other people)	Fine motor	Virtual (e.g. imagining poking another person)	None	One-to-one
					One-to-many
		Gross motor	Virtual (e.g. imagining the gross motor movement of another person)	None	One-to-one
					One-to-many

Sensory	Mental	Motor	Spatial	Media	Social
Visual	Cognitive (i.e. used to perceive visual information)	Fine motor (i.e. moving fingers in line with what is seen on screen)	Real (i.e. looking at the physical screen)	Digital (i.e. iPhone)	None
			Virtual (i.e. looking at the text and images in the Messages app)	Digital (i.e. iPhone)	None
	Imaginative (i.e. used to imagine visual scenes)	Fine motor (e.g. imagining visuals involving fine motor movement)	Virtual (i.e. imagining what other people are doing)	None	One-to-one
					One-to-many
		Gross motor (e.g. imagining visuals involving gross motor movement	Virtual (i.e. imagining what other people are doing)	None	One-to-one
					One-to-many

Evaluation of Version 4

With Version 4, it was understood that the model would be used to map the perceived interactivity of the individual who was having the experience. This means that the appearance of the completed model could differ, depending on the individual completing the model and/or the context of the experience.

Version 4 of the model was successfully tested on all nine scenarios. However, six main issues were brought to light during testing. These concerned the following:

» The lack of clarity in the labelling and design of the model;

» The affective interactivity dimension was always shaded;

» The inability to distinguish between interactivity that is subconscious and conscious, or reflexive (i.e. automatic responses that occur on reflex) and critical (i.e. intentional responses to stimuli, resulting from careful consideration and analysis);

» The shading of the segments when no dimensions are shaded in the inner adjacent ring;

» The inability to show the level of interactivity; and
» The inability to differentiate between synchronous and asynchronous interactivity.

Lack of clarity in the labelling and design of the model

The lack of clarity relates to two main characteristics. First, the segments belonging to each individual sensory dimension are too close together and this makes it difficult to differentiate between them. Second, the individual segments are not labelled clearly enough and it is difficult to remember the sub-dimensions that each segment represents.

Affective interactivity dimension was always shaded

The affective interactivity dimension was shaded in every scenario and does not distinguish between different affective types. Consequently, it seems redundant to include it as a dimension in the model as it not only makes it unnecessarily more complex, but also does not really serve a real purpose (since one can simply assume it is always present; an affective dimension segment is not needed for this to occur).

Inability to distinguish between interactivity that is subconscious and conscious

As Scenario 6 involved a dream experience (see Figure 43), it showed that Version 4 of the model did not allow for subconscious mental interactivity to be differentiated from conscious interactivity. In other words, it does not allow for the differences between the interactivity when a person is engaged in dreaming while asleep (subconscious) and the interactivity when a person is engaged in imagining something while awake (conscious) to be visually represented. Although this would be of value, consciousness is more suitably defined as a characteristic of interactivity because it relates to more than one dimension of interactivity. For example, it is possible for both conscious motor interactivity and subconscious mental interactivity to occur simultaneously. In order for the model to be able to depict the difference in consciousness for each of these dimensions, consciousness must be viewed as a characteristic rather than a dimension of interactivity. As such, it will be excluded from the model of interactivity.

Shading of the segments when no dimensions are shaded in the inner adjacent ring

This issue occurred in relation to media interactivity and social interactivity, as well as in relation to sensory interactivity and motor interactivity. In relation to the former, if media interactivity is absent but social interactivity is present, the difficulty arises when trying to determine which social interactivity segment to shade since both the media interactivity segments are blank. (The convention was to shade the social interactivity segments adjacent to a shaded media interactivity segment.) Clearly, it would be misleading to shade the one-to-many (social interactivity) segments connected to both the digital and non-digital (media interactivity) segments. Shading the segments adjacent to the unshaded non-digital (media interactivity) segments was ultimately deemed most appropriate because the absence of media is non-digital (see Figure 46 for an example).

With regard to the latter, the same problem reoccurs in the olfactory and gustatory areas, where motor interactivity is absent, but spatial interactivity is present. In this case the real-life (spatial interactivity) segment linked to the fine motor (motor interactivity) segment was shaded, since eating mainly involves fine motor rather than gross motor movement (see Figure 37).

Inability to show the level of interactivity

The Scenario 5 test highlighted this issue as it involved the use of virtual reality (see Figure 42). On one hand, it could be argued that virtual reality should be seen as having more interactivity since it results in visual and auditory immersion. The counterargument to this, however, would be that the visual and auditory immersiveness of virtual reality is not the result of more interactivity, but of higher quality visuals and audio. To address this, the model could be adjusted to show the level of the sensory interactivity or reflect the differences in the quality of the sensory information present in an experience. It is recommended that this be done in future research instead of here in this research. Version 4 of the model already consists of 591 segments, and breaking these down further in order to show the level of interactivity would make the segments too small to be properly visible. Although moving to an interactive three-dimensional model can address this issue—one could 'zoom into' or 'click on' each segment to view additional information (e.g. level of interactivity, quality of sensory information, etc.)—it is likely that making the model so complex in this early stage of its existence would result in it becoming too difficult to understand, thereby inhibiting its adoption and use.

Inability to differentiate between synchronous and asynchronous interactivity

Of the nine scenarios tested, Scenario 9 (see Figure 46) was the only one that involved asynchronous interactivity (where the interactivity between two parties does not occur simultaneously in real time). This highlighted that Version 4 does not allow time or synchronousness[122] to be represented. Since technology now allows for both asynchronous and synchronous learning, there is growing interest in how synchronisation influences the type and quality of learning (Hrastinski 2008; Offir, Lev, and Bezalel 2008). This suggests synchronousness is important. However, upon further consideration it was realised that synchronousness was better defined as a characteristic of interactivity because synchronousness can apply to more than one dimension of interactivity. For example, one might be interacting with Person A synchronously in real life while at the same time interacting with both Person B asynchronously in a digital space. In order for the model to accurately display which dimensions of interactivity are occurring synchronously and which are occurring asynchronously at the same time, synchronousness must be viewed as a characteristic of each of the dimensions of interactivity rather than a dimension in itself. As such, it was decided that synchronousness would not be included in the model of interactivity.

Changes recommended for Version 5

The Version 4 tests showed that the new design of the model was relatively successful, although it also revealed that a minor adjustment in its structure was necessary to address some of the issues that arose. Verison 5 is the result of the adjustments that were made to Version 4. The following changes were recommended for Version 5:

» Establish a method of shading segments when adjacent segments are unshaded;
» Separate the segments belonging to each individual sensory dimension and improve the method of labelling the model; and
» Remove affective interactivity segment.

It must be mentioned that not all of the issues in Version 4 were addressed in Version 5. The inability to distinguish between interactivity that is subconscious and conscious, the inability to show the level of interactivity, and the inability to differentiate between synchronous and asynchronous interactivity were not addressed in Version 5. They will also not be addressed in this research. This is because there were concerns that this would add to the existing complexity of the model, and attempting to resolve this issue is considered too difficult given the expected scope of this research.

[122] This refers to the quality of being synchronous and asynchronous; it should not be confused with Carl Jung's concept of synchronicity.

Model of interactivity—Version 5

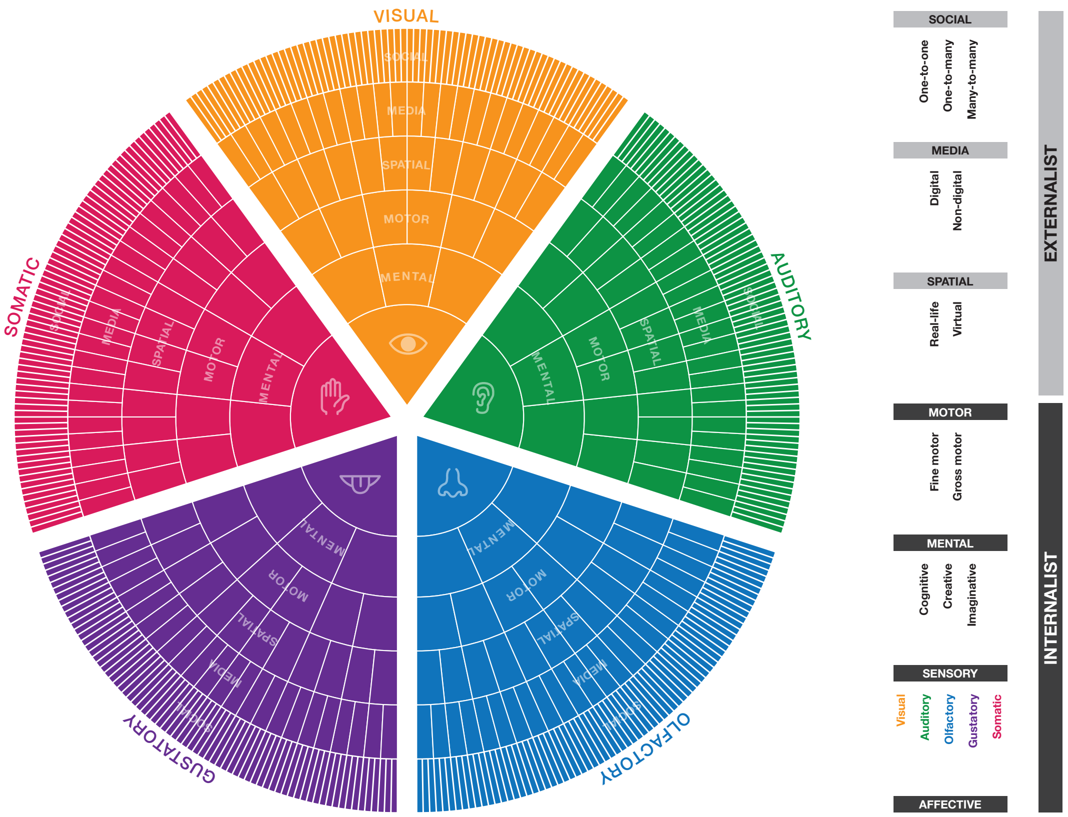


Figure 47: Model of interactivity—Version 5 (colour)

Version 4 was refined further to produce Version 5. Figure 47 shows Version 5 with all the sub-dimension segments filled in with colour. The refinements included changing the colours of each sensory sub-dimension, separating the sensory sub-dimensions, adding titles and a key to the model, and removing the affective dimension segment. The main purpose of these refinements was to reduce the visual complexity of the model and make it easier to read.

The colours in Version 5 were altered to make the difference between the colours of each sensory sub-dimension more distinct. The segments relating to each sensory sub-dimension were separated for visual clarity, and titles added to the rings. To make the model easier to read, a key was added on the right to indicate the breakdown of the segments in each dimension ring, showing the order of placement of the segments (from left to right) and the name of the segments in each ring. The affective dimension segment was removed because it was considered to be unnecessary, and this would reduce the complexity of the model at the same time.

Model of interactivity—Version 5 testing

In Version 5, the circular model from Version 4 was adjusted so that the interactivity dimensions linked to each sensory interactivity sub-dimension were separated from each other (like slices of pie). The rings and the segments within each pie section remained the same, except that the affective dimension segment was removed. To improve the clarity of the model, the name of each interactivity dimension ring was labelled and a key was added on the right of the model. The key listed in order from top to bottom the names of each of the interactivity dimension rings (from outermost to innermost). Under each interactivity dimension, the sub-dimensions were listed from left to right. As with Version 4, the segments of the interactivity sub-dimensions that are present are shaded in colour and those that are absent are left uncoloured in a light grey.

Version 5 of the model was successfully tested on each of the nine scenarios (see Figure 48–Figure 56). These tests are based on the same tables used in the Version 4 tests. As such, it was not seen as necessary to repeat the tables and the explanations behind each of the interactivity dimensions and sub-dimensions that were shaded. Since all the Version 5 tests were successful, this version of the model was considered sufficiently resolved. Consequently, this version is presented in Chapter 5 as the final version of the model of interactivity.

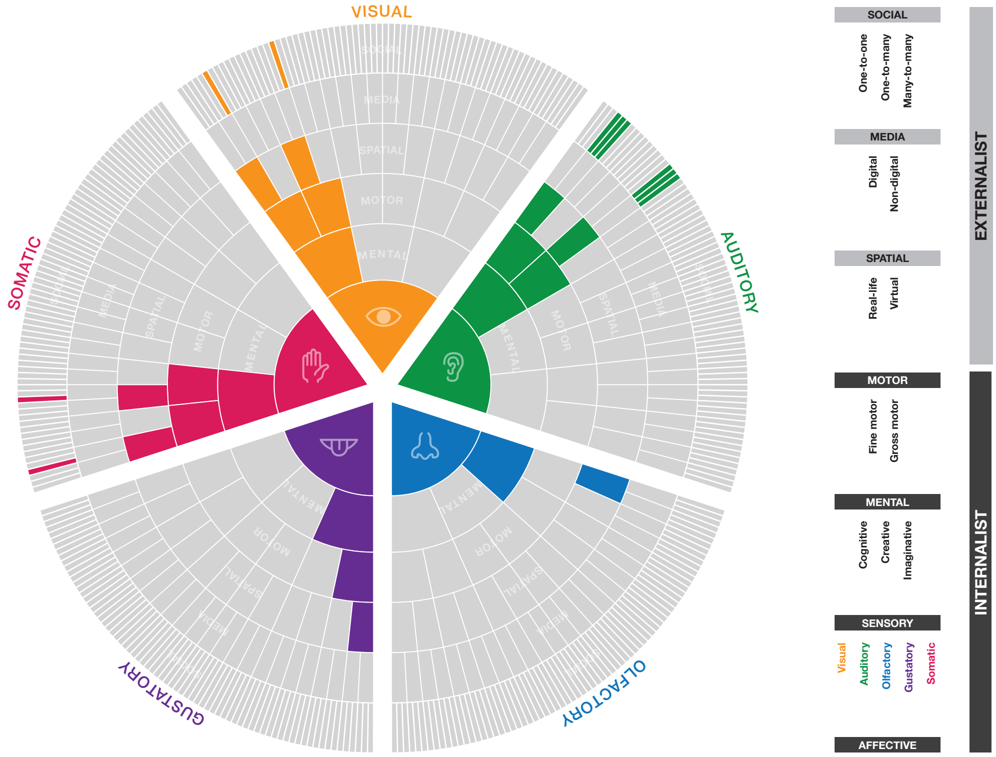


Figure 48: Test of Version 5 on Scenario 1 (Eating with family in real life)

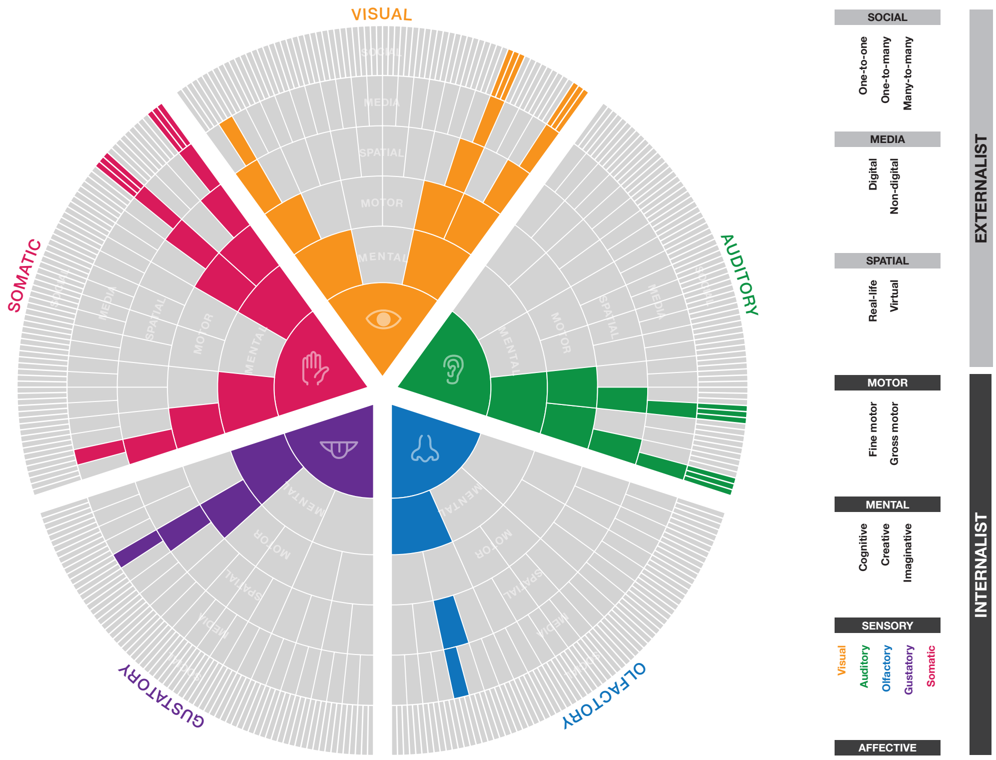


Figure 49: Test of Version 5 on Scenario 2 (Silent reading of the printed book The Hundred-Foot Journey*)*

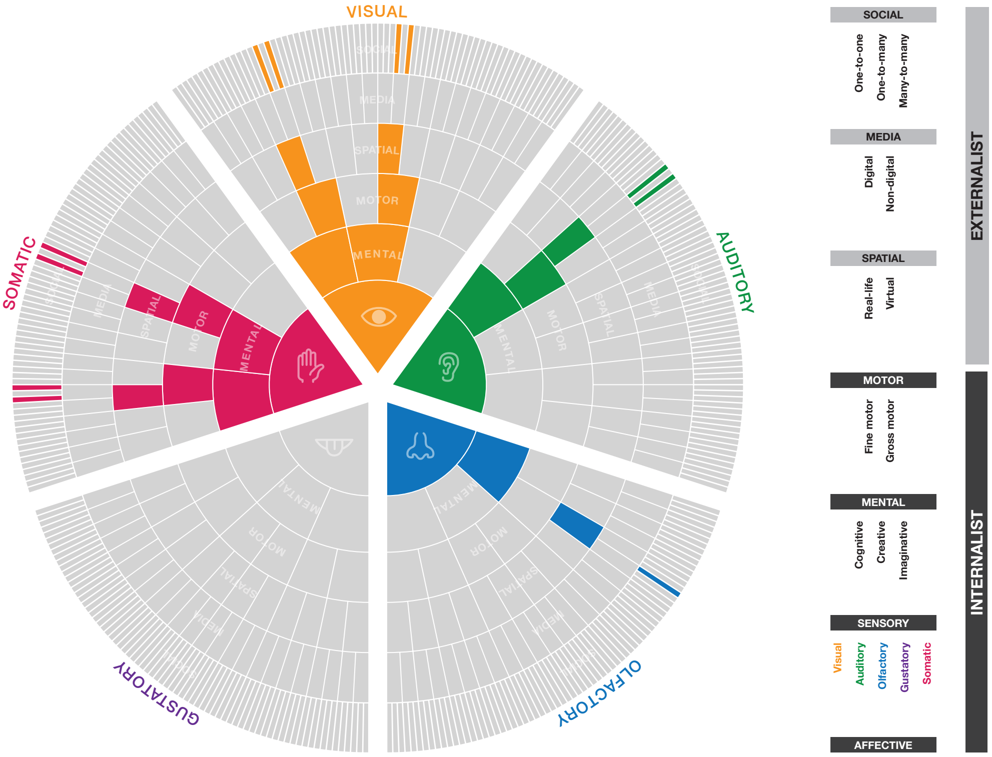


Figure 50: Test of Version 5 on Scenario 3 (Playing 3-on-3 basketball in real life)

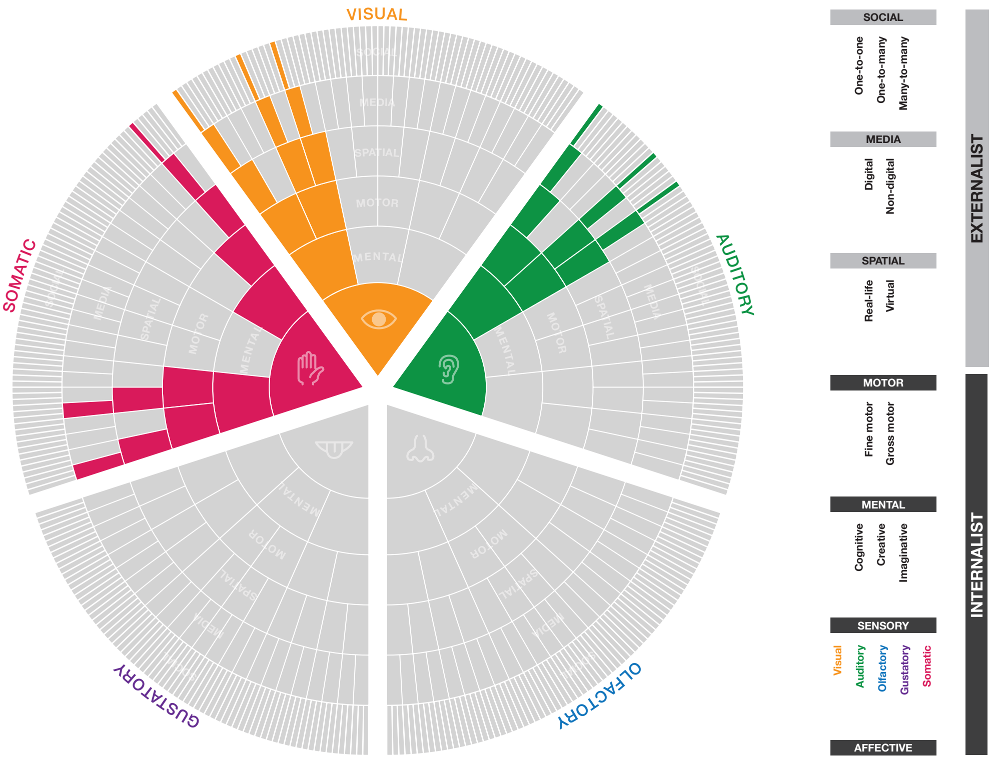


Figure 51: Test of Version 5 on Scenario 4 (Playing 3-on-3 basketball in the Wii Sports Resort *game)*

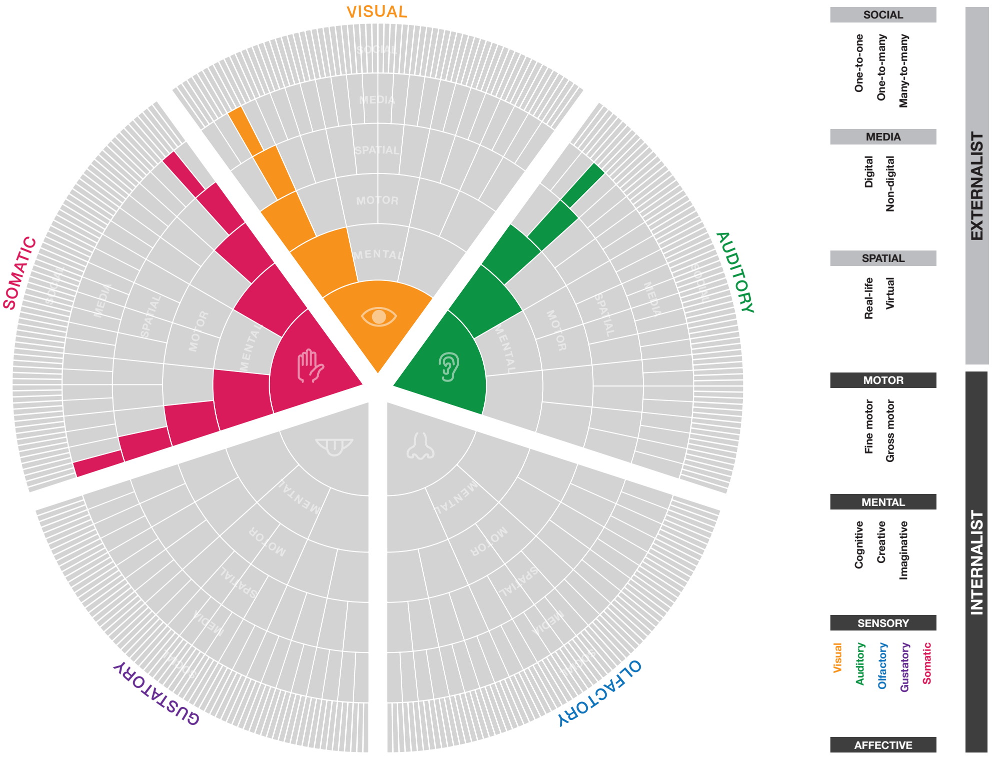


Figure 52: Test of Version 5 on Scenario 5 (Playing the Driveclub VR *game using the Playstation VR and Playstation 4)*

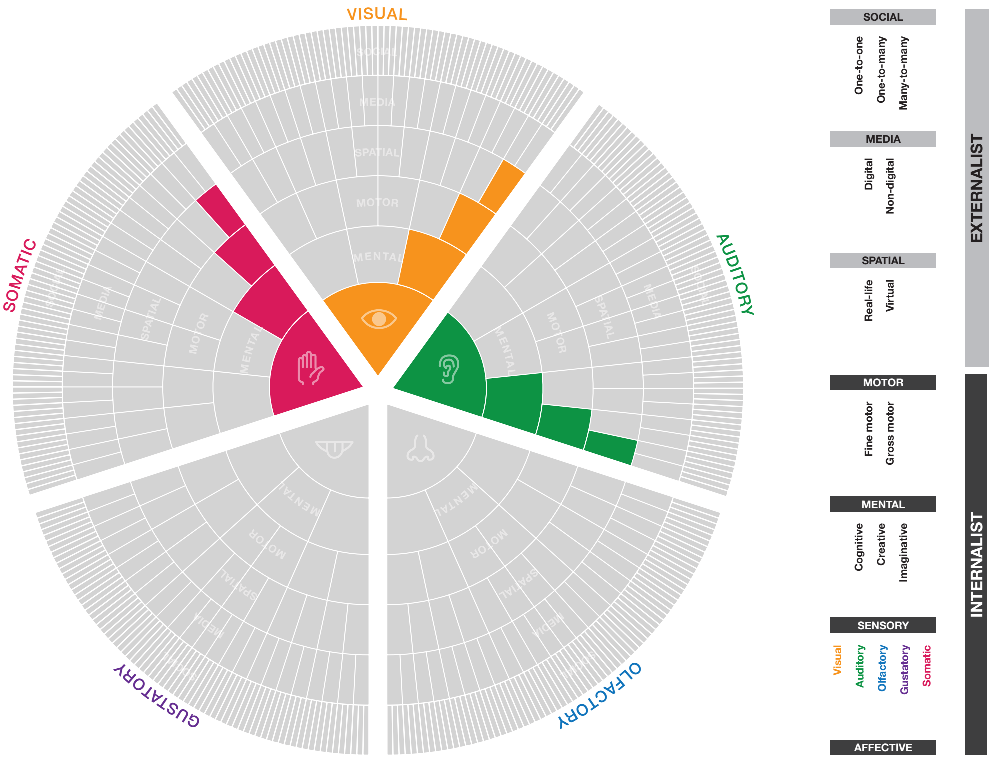


Figure 53: Test of Version 5 on Scenario 6 (Driving in a dream)

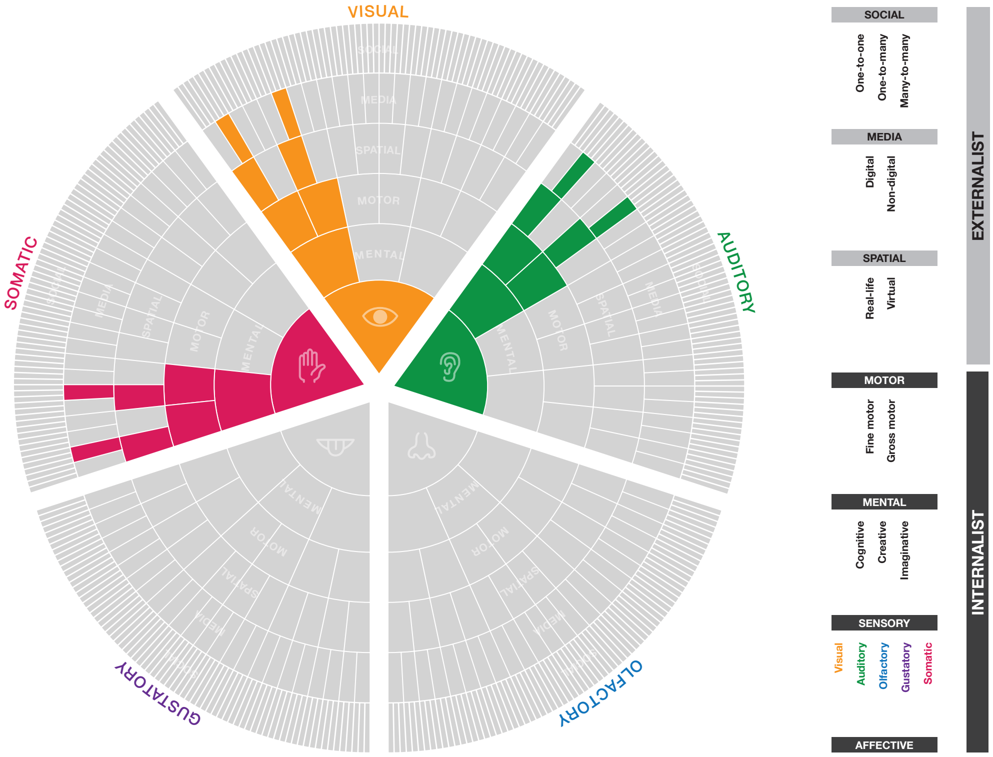


Figure 54: *Test of Version 5 on Scenario 7 (Playing Beethoven's* Für Elise *on the piano while referring to printed sheet music)*

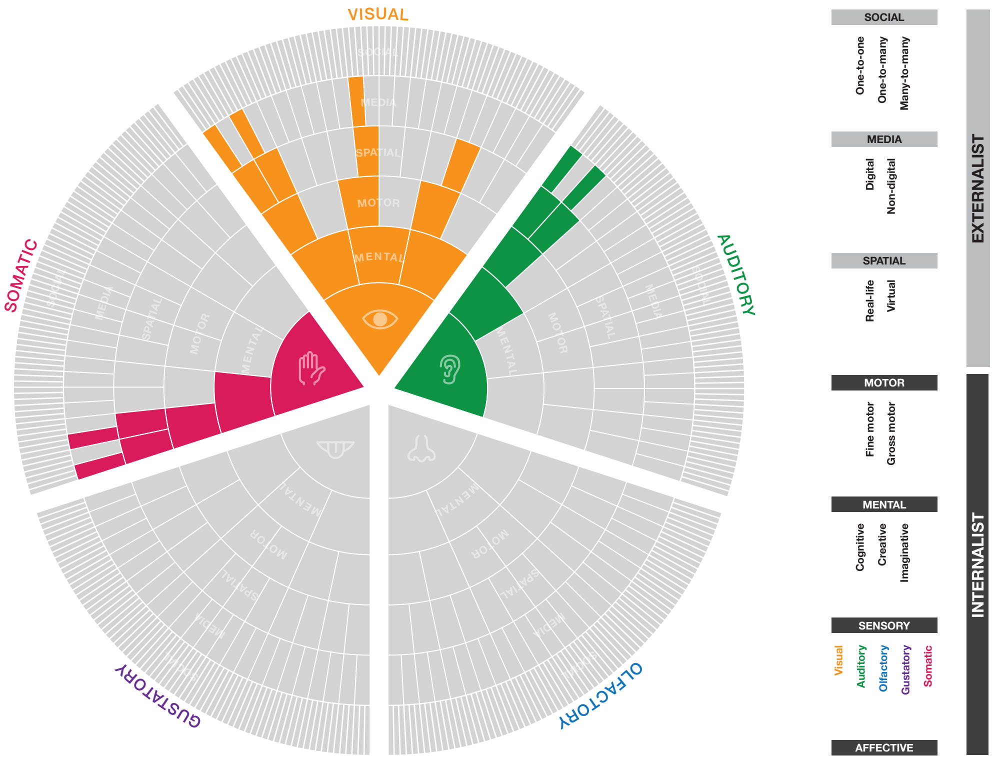


Figure 55: Test of Version 5 on Scenario 8 (Painting using Photoshop on a Macbook Air)

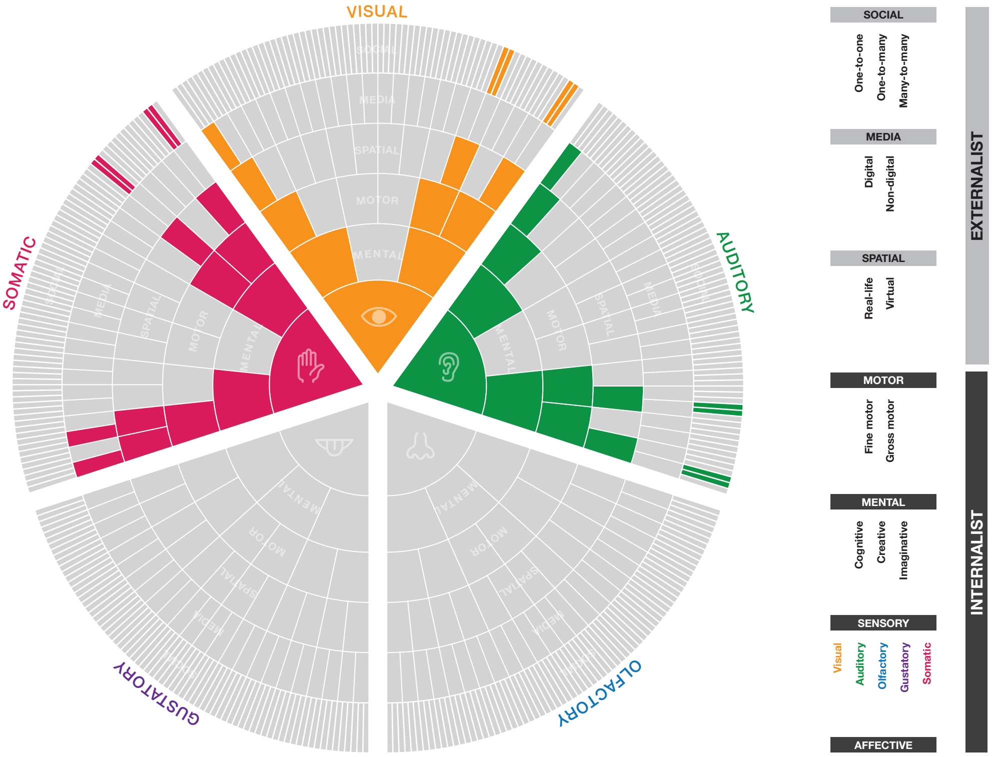


Figure 56: Test of Version 5 on Scenario 9 (Texting with friends via an iPhone)

06

THE MODEL OF INTERACTIVITY

The final model of interactivity

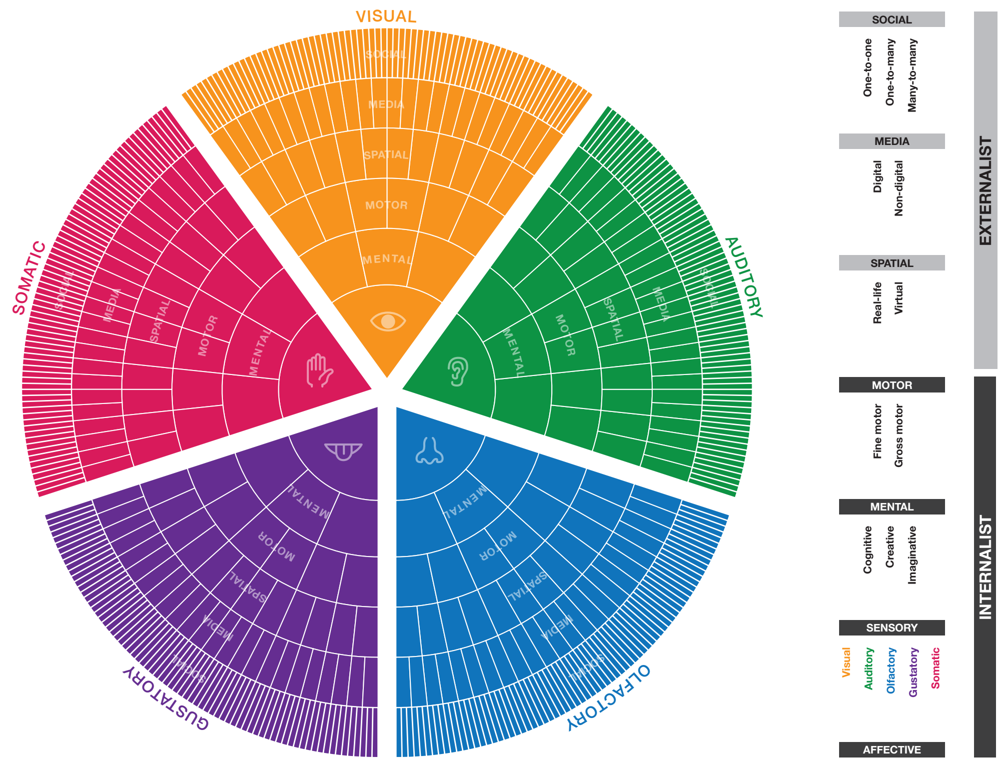


Figure 57: The final model of interactivity

Figure 57 shows the final model of interactivity. The dimensions of interactivity are categorised as internalist or externalist. The internalist dimensions include: affective, sensory, mental, and motor. The externalist dimensions include: spatial, media, and social. The key on the right of the model shows the arrangement and names of each dimension and sub-dimension. Although affective interactivity[123] is not depicted in the final model, it is still listed as an internalist

[123] As mentioned previously, this is not detailed in this model and will instead be covered in subsequent post-doctoral research.

dimension in the key. This is because it is understood that affective interactivity is present all the time but, as mentioned previously, the complexities involved in trying to show the relationship between different affective dimensions (or emotions) and the other interactivity dimensions prevented it from being included in the model.

Thus, the three inner rings in the model are the internalist dimensions of interactivity. The ring in the centre represents sensory interactivity; it is divided into five sections: visual, auditory, gustatory, olfactory, and somatic. The second ring is mental interactivity and has three sub-dimensions: cognitive, creative, and imaginative. The third ring is motor interactivity and has two sub-dimensions: fine motor and gross motor. The outer three rings are the externalist dimensions of interactivity. The fourth ring is the first externalist dimension, spatial interactivity. It has two sub-dimensions: real-life and virtual. The fifth ring is media interactivity and has two sub-dimensions: digital and non-digital. The sixth and outermost ring is social interactivity and has three sub-dimensions: one-to-one, one-to-many, and many-to-many.

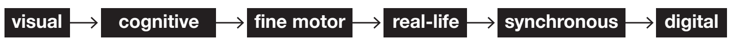


Figure 58: Linear flowchart of connections between dimensions

The model is able to show the interconnections between and intraconnections within each ring. An example of the interconnections between rings is shown in the linear flowchart in Figure 58. The partially completed model in Figure 59 shows how the linear flowchart in Figure 58 would look when mapped in the model. It is worth noting that Figure 58 and Figure 59 show only a fraction of the interactivity present when engaged in texting on a mobile phone. Here, visual interactivity is present (i.e. looking at the screen and buttons). This is connected to cognitive interactivity (i.e. thinking of what buttons to press or what to type, etc.) and, in turn, linked to fine motor interactivity (i.e. using fingers to press buttons). Since the fine motor movement is occurring in real life and on a digital device, the fine motor interactivity is linked to real-life spatial interactivity, which is connected to digital media interactivity. All of these interactivity dimension segments were shaded accordingly. No social interactivity dimensions were shaded since there is no social interactivity happening in real life.

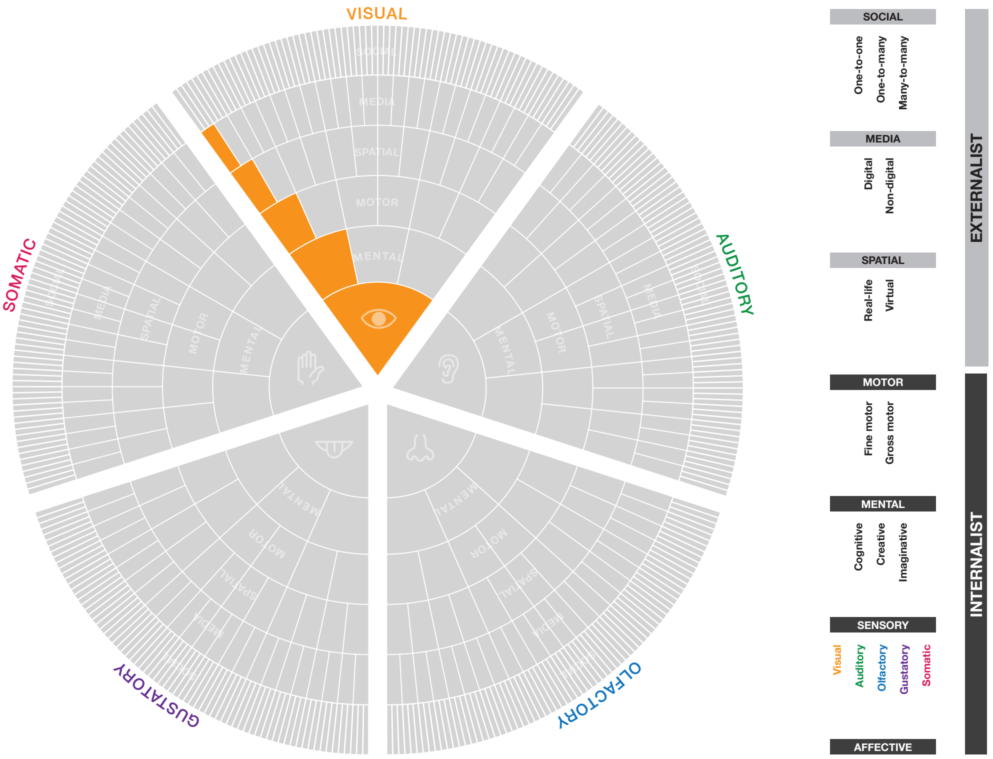


Figure 59: Partially completed model that parallels linear flowchart

Internalist dimensions of interactivity

The internalist dimensions of interactivity refer to those dimensions that are directly related to the body of the individual who is engaged in an experience. The use of the term 'internalist' is derived from the internalist approach to aesthetics (see page 36). There are four internalist dimensions of interactivity: affective, sensory, mental, and motor. The first three dimensions were categorised as internalist dimensions because multiple references have been made to their significance and their relationships with each other. Schmitt, for example, described customers as wanting products "that dazzle their senses, touch their hearts and stimulate their minds" (Schmitt 1999, cited in Hassenzahl 2005, 31). Wright, McCarthy and Meekison (2005) also referred to the affective, sensory, and mental dimensions. Their proposed framework for analysing user experience involved first describing an experience using four threads of experience and then considering how the user makes sense of an experience. These four threads of experience were: compositional, sensual, emotional and spatio-temporal[124] (46), of which the first three threads relate to the first three internalist dimensions proposed above.

[124] The spatio-temporal thread relates to the spatial and temporal dimensions in the externalist category.

Like Wright, McCarthy and Meekison (2005), Sohn (2011) also acknowledged the role of interpreting meaning in perceived interactivity. While Wright et al. referred to this as compositional, Sohn referred to it as semantic. However, neither of their frameworks addressed the role of thinking in the process of making meaning. Thinking enables us to process and derive meaning from sensory information. This is why mental interactivity is included as a dimensions in the model of interactivity.

Finally, the fourth dimension, motor interactivity, is seen here as the visible manifestation of the first three internalist dimensions of interactivity. This relationship was also recognised by Sohn (2011), whose framework included sensory, semantic, and behavioural dimensions of interactivity. This proposed framework acknowledged the role of behavioural engagement in interactivity by including a behavioural dimension. It also influenced the final model by illustrating that sensory perception, thought, and movement are required[125] for behavioural engagement to occur. Thus, movement was included in the final model as motor interactivity.

Affective interactivity

Note: Although affective interactivity is not included in the model, it is still recognised as an internalist dimension and is included in the discussion here because of its significant relationship with the other dimensions.

All of us interact emotionally with what is around us, be it our environment, other people, animals, or digital devices. This is affective interactivity. Affective interactivity is present when there is an affective (or emotional) response; if there is no affective response, affective interactivity is not present. For affective interactivity to be present, at least one participant must have an affective response. However, this does not mean that all participants have to. It is important to note that the absence of an affective response to an experience can be useful, particularly when it occurs in contexts where an affective response is typical or expected.

Affective interactivity can occur even when there is no physical interaction (e.g. touching). For example, affective interactivity is present when we view a photograph of a baby, if viewing the photograph produces an affective response. Affective interactivity is also present when we are watching a live football match, if watching the match produces an affective response. The presence of affective interactivity is related to the individual viewer/player/user participating in

[125] The relationship between sensory perception, thought, and movement is discussed in detail on page 145.

the experience. Where more than one viewer/player/user is participating, affective interactivity is linked to the person whose point of view it is.

Sensory interactivity

Sensory interactivity refers to the interactivity that is present when we use our senses during an experience. It can occur whether we are interacting with real people, places, and objects, or with virtual ones. In the final model, sensory interactivity is divided into five sub-dimensions[126]: visual, auditory, gustatory, olfactory and somatic.

Visual interactivity

Visual interactivity refers to the interactivity that is present when we use our sense of sight during an experience. It is present when we are looking at a painting, when we are imagining the view of the ocean at our last holiday, and when we are reading a book.

Auditory interactivity

Auditory interactivity refers to the interactivity that is present when we use our sense of hearing during an experience. It is present when we are listening to music, when we are having a conversation with another person (which involves listening and speaking), and when we are playing the piano.

Gustatory interactivity

Gustatory interactivity refers to the interactivity that is present when we use our sense of taste during an experience. It is present when we are drinking a hot coffee, when we are kissing someone, and when we are imagining the taste of a chocolate brownie.

Olfactory interactivity

Olfactory interactivity refers to the interactivity that is present when we use our sense of smell during an experience. It is present when we are remembering the smell of the fresh bread from our local bakery, when we catch a whiff of the perfume a stranger is wearing, and when we imagine the smell of bacon after seeing a photo of crispy bacon in a friend's Facebook post.

Somatic interactivity

[126] There have been suggestions (e.g. Jarrett 2014) that we have more than five senses, but this beyond the scope of this thesis.

The term ‘somatic’ was chosen to describe touch-related interactivity because it seemed most fitting, based on the description of somatic senses in the Guyton and Hall Textbook of Medical Physiology (Hall and Guyton 2016 , emphasis in the original):

> [the] somatic senses are the nervous mechanisms that collect sensory information from all over the body. These senses are in contradistinction to the special senses, which mean specifically vision, hearing, smell, taste, and equilibrium. (607)

Thus, somatic interactivity refers to the interactivity that is present when we use our sense of touch during an experience. It is present when we are touch-typing on a keyboard, when we feel the texture of fur, and when we feel the pain of an electric shock.

Mental interactivity

Mental interactivity refers to the interactivity that is present when we use our mind during an experience. Mental interactivity is divided into three sub-dimensions: cognitive interactivity, creative interactivity and imaginative interactivity. Each of these sub-dimensions is distinct from the other. One or more sub-dimensions of mental interactivity can be present at any given time. Each sub-dimension of mental interactivity is explained below.

Cognitive interactivity

Cognitive interactivity refers to the interactivity that is present when we use our mind’s cognitive ability during an experience. Cognitive interactivity occurs when an individual uses one or more cognitive skills[127] in order to interact—or in the course of interacting—with a person, place, or object. It is present when we are working on a math problem, when we are trying to remember someone’s name, and when we are reading.

Creative interactivity

Creative interactivity refers to the interactivity that is present when we use our mind’s creative ability during an experience. It occurs when we come up with ideas that are not prescribed, but are spontaneous (and, in cases of extreme creativity, innovative). Creative interactivity frequently occurs together with cognitive interactivity. For example, when designing a poster, creativity is used together with the “synthesis”/”create” cognitive skill from Bloom’s taxonomy.

[127] See examples of cognitive skills in Bloom’s Taxonomy on page 302.

Imaginative interactivity

Imagination—or the ability to generate images in the mind—was referred to as phantasia by Aristotle (Shields 2016). Imaginative interactivity refers, therefore, to the interactivity that occurs during this process of generating mental images, such as when reading a book. Imaginative interactivity relates to the reader's ability to bring words to life, by using his or her imagination to translate the words into mental images. As Everding (2009) reported, "A new brain-imaging study is shedding light on what it means to 'get lost' in a good book — suggesting that readers create vivid mental simulations of the sounds, sights, tastes and movements described in a textual narrative while simultaneously activating brain regions used to process similar experiences in real life."

Adam Zeman, Michaela Dewar and Sergio Della Sala's (2015) discovery of aphantasia indicates that imaginative interactivity is distinct from cognitive interactivity. People with aphantasia are unable to "summon up mental images" (Zimmer 2015). Aphantasia does not affect memory or problem-solving ability, nor does it have anything to do with blindness. This suggests that the ability to imagine is separate from cognitive abilities such as memory. Thus, imaginative interactivity refers to the interactivity that is present when we use our mind's imaginative ability during an experience. It is present when the imagination is used to produce a mental image—for example, when we read a book. Imaginative interactivity is different from creative interactivity and cognitive interactivity, but is often present in conjunction with one or both of them.

Motor interactivity

Motor interactivity refers to the interactivity that is present when we move our bodies during an experience. It takes into account only voluntary conscious movement, not involuntary subconscious movement (e.g. heart beating, knee-jerk reactions, etc.). Motor interactivity is divided into two sub-dimensions: fine motor and gross motor. It can be present whether or not there is physical contact. Motor interactivity can occur in both real life and our imagination.

Fine motor interactivity

Fine motor interactivity refers to the interactivity that is present when we use fine motor movement during an experience. Fine motor movements are seen as exploratory hand movements (Lederman and Klatzky 1987). It is present when we using a game controller, when we are writing with a pen, and when our eyeballs track left and right to read a book.

Gross motor interactivity

Gross motor interactivity refers to the interactivity that is present when we use gross motor movement during an experience. Gross motor movement refers to body movements involving the whole body, such as described in Laban (2011). It is present when we swing a baseball bat, when we run and jump, and when we dance.

Externalist dimensions of interactivity

The externalist dimensions of interactivity refer to those dimensions that are external to the body of the individual who is engaged in an experience. Externalist interactivity derives its name from the externalist approach to aesthetics (see page 74). It can also be thought of as the context of the experience. There are three dimensions of externalist interactivity: spatial, media, and social.

Spatial interactivity

Spatial interactivity refers to the interactivity that is present when we interact with the space around us during an experience. It is divided into two sub-dimensions: real-life and virtual.

Real-life interactivity

Real-life interactivity refers to the interactivity that is present when we interact with the space around us during an experience in a real-world environment. It is present when we dance in the rain in real life, when we eat food in real life, and when we hug a person in real life.

Virtual interactivity

Virtual interactivity refers to the interactivity that is present when we interact with the space around us during an experience in a virtual environment. It is present when we play video games on television, when we are using a VR headset, and when we are dreaming.

Media interactivity

Media interactivity refers to the interactivity that is present when we use media during an experience. Media interactivity is divided into two sub-dimensions: digital and non-digital. Having only two sub-dimensions allows this dimension to be generic enough to be applied to almost any experience, analogue or digital. It also means it is not limited to devices or media that have already been invented, and is able to accommodate new media types, including those that combine both digital and non-digital media (e.g. Robles and Wiberg 2010; Ishii et al. 2012; McEvoy and Correll 2015).

Examples where digital media interactivity is present include playing a video game, doing word processing on a computer, watching television, and using a smartphone. Examples where non-digital media interactivity is present include reading a book, viewing a billboard, and writing a letter.

Social interactivity

Social interactivity refers to the interactivity that is present when we interact with other people during an experience. There are three sub-dimensions of social interactivity: one-to-one (occurs between two individual users), one-to-many (occurs between an individual user and a large group of other individual users), and many-to-many (occurs within a large group of individual users).

07

EVALUATING THE MODEL

Using the model on the Learning Experience Scenarios

Having finalised the model of interactivity, this section evaluates the final model by using it to map three chosen Learning Experience Scenarios (LES). For each LES, a description of the LES will be provided, followed by a completed model that maps the interactivity in the LES, as well as a written explanation of the completed model. The descriptions will be written in first person, for ease of explanation. The Learning Experience Scenarios will be evaluated collectively at the end of this section.

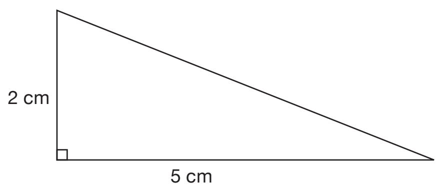
LES 1: Doing a printed math worksheet

Name: ____________________ Date: ____________________

1. 2 x 30 = ___________

2. Write 4¾ as an improper fraction. $\frac{\square}{4}$

3. What is the area of the triangle below? ___________



4. 30/100 = 0.3 = thirty hundredths Circle: True or False

5. What is the highest common factor of 24 and 40? ___________

Figure 60: Example of a printed math worksheet

Description of Learning Experience Scenario 1

In Learning Experience Scenario 1 (LES 1), I am doing a printed math worksheet by myself, rather than in a group. This is typical of how worksheets are used in classrooms. A printed math worksheet typically consists of a series of sums on a page (see Figure 60). With colour printing being significantly more expensive than black-and-white printing, worksheets are usually black-and-white photocopies or printouts. A math addition worksheet was selected for LES 1 so it can be compared with Learning Experience Scenario 2 (i.e. the World Challenge in the Live Mathletics learning option), which also involves math addition. LES 1 is different from the other learning experience scenarios because the learner has to work alone and does not have a choice of learning options. This is common in many classroom environments where the teacher controls the learning activities.

Application of model to Learning Experience Scenario 1

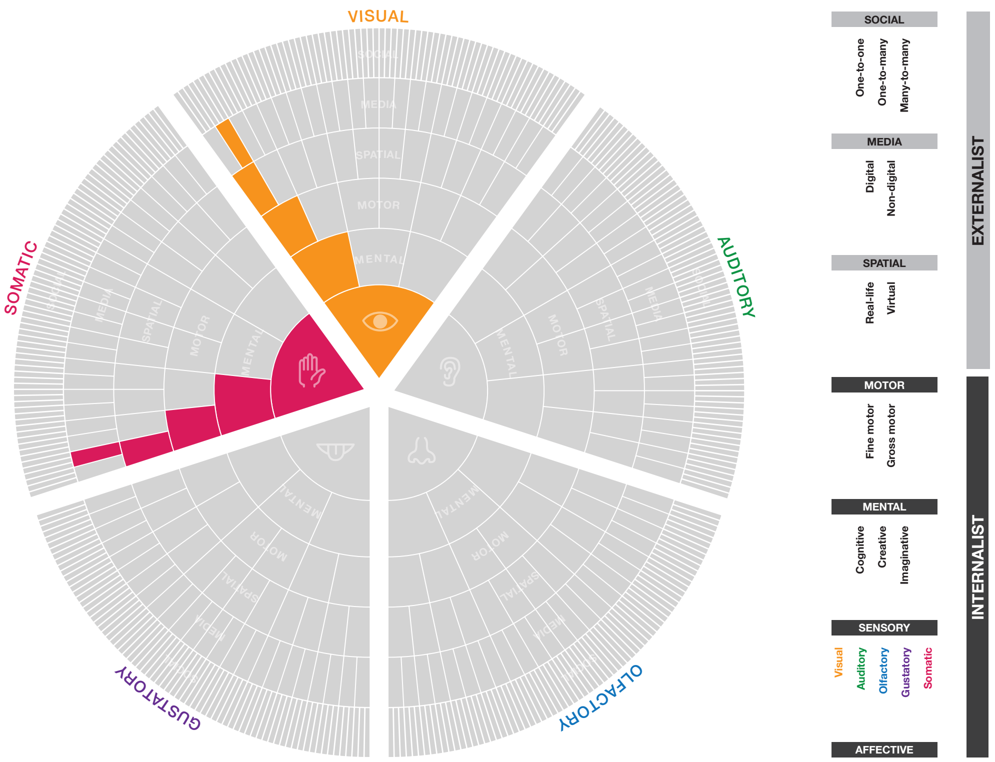


Figure 61: Applying the model of interactivity to LES 1

Figure 61 shows the model as applied to LES 1. Here, only two sensory interactivity sub-dimensions are present: visual interactivity and somatic interactivity. Visual interactivity is present because I have to look at the printed symbols (i.e. numbers, plus sign, etc.) on the worksheet to interpret them, and also to see what I am writing. Somatic interactivity is present because I use my sense of touch to interact with the worksheet and my pencil.

The mental interactivity that is linked to visual interactivity is cognitive, since cognitive skills are needed to complete the worksheet. These include using memory (i.e. remembering what the symbols represent), constructing mental models (i.e. understanding how addition works), and problem-solving (i.e. figuring out which numbers added together produce which numbers). The mental interactivity linked to somatic interactivity is also cognitive. However, the cognitive skills required are somewhat different. Even though memory is also required here, for instance, the task is different (i.e. remembering the shape of the numbers and how to move the pencil to produce them on paper).

The motor interactivity linked to both the visual and somatic interactivity is fine motor. In relation to visual interactivity, it involves the movement of my eyeball to read what is on the worksheet and to write, as well as the movement of my fingers and hand which must sync with what I see so I can write legibly. In relation to somatic interactivity, it involves the movement of the fingers and hand as necessitated by the act of writing.

The spatial interactivity linked to both visual-motor and somatic-motor interactivity is real-life, since they both involve interacting in the real world with real-life objects rather than with virtual ones. The media interactivity is non-digital, since a non-digital print medium is being used. There is no social interactivity here since the worksheet is being completed individually.

LES 2: Playing World Challenge in Live Mathletics on a Macbook Air

Description of Learning Experience Scenario 2

In Learning Experience Scenario 2 (LES 2), I will be playing World Challenge in Live Mathletics on a Macbook Air, competing online with other learners from around the world. Mathletics is a mathematics learning website based in Australia. It is used by schools and families worldwide. Figure 62 shows a screenshot of the Mathletics homepage. Mathletics offers a range of learning options: Live Mathletics, Activities, Problem Solving, Concept Search, Rainforest Maths, Prepare for NAPLAN and Times Tables Toons. These are found in right-hand column shown in Figure 63.

Figure 62: Mathletics homepage (screenshot taken July 2015)

Figure 63: Mathletics learning options—part 1 (screenshot taken July 2015)

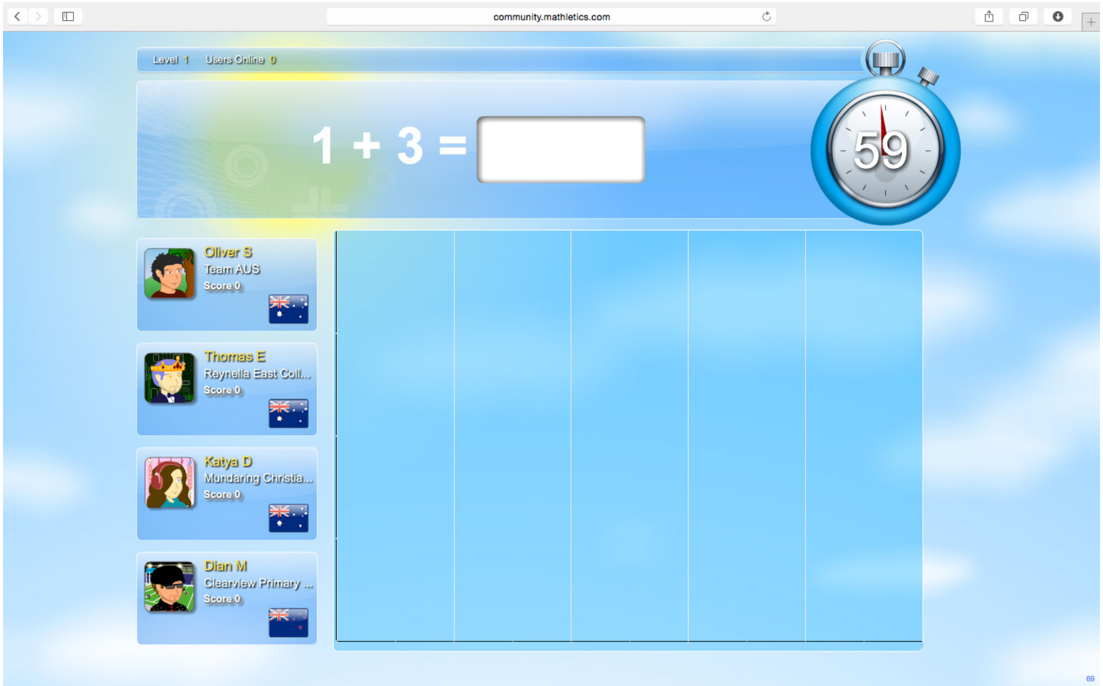


Figure 64: Live Mathletics (screenshot taken July 2015)

Each learner has a personal account that they log into. Once logged into their account, learners are asked to customise an illustrated avatar, which is then used as their public profile image when they compete online (i.e. World Challenge) in Live Mathletics with other learners (see Figure 64). In the World Challenge option of Live Mathletics, each learner competes against other learners from around the world with similar levels of ability, online and in real-time. Learners are given a series of math problems to solve within 60 seconds. The goal is to give as many correct answers as possible before the time runs out. Each learner is then awarded points for each correct answer, and additional points are given if the learner has the most points (i.e. comes in first) or if the learner gets a new high score (i.e. exceeds than their existing high score).

Application of model to Learning Experience Scenario 2

Figure 65 depicts the model as applied to LES 2. When Figure 65 is compared with Figure 61, it is is clear that more interactivity present in LES 2 than in LES 1. In LES 2, there are three sensory interactivity sub-dimensions present: visual interactivity, auditory interactivity, and somatic interactivity. Visual interactivity is present because I have to look at the images and text on the screen, and also at the keyboard. Auditory interactivity is present because I use the sound of the keyboard to track whether the keys have been pressed. Somatic interactivity is present because I use my sense of touch to interact with the keyboard.

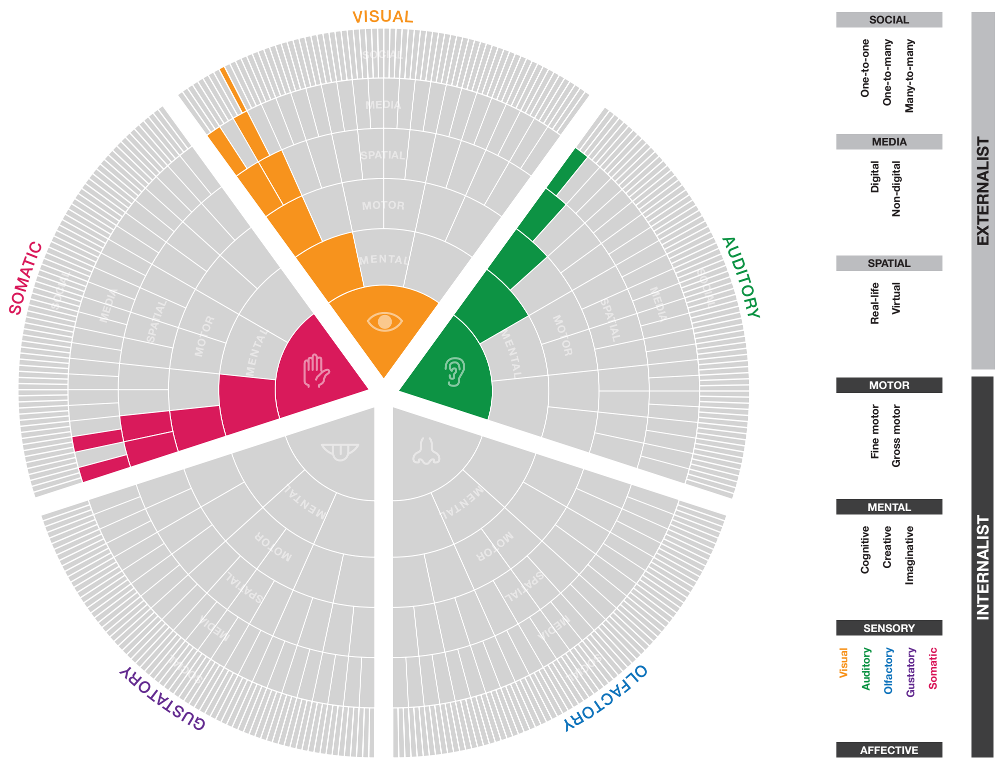


Figure 65: Applying the model of interactivity to LES 2

In relation to visual interactivity, the mental interactivity is cognitive; cognitive skills are needed to come up with the answers to the World Challenge questions. Because speed is a factor here, the main skill required is memory (i.e. remembering which numbers added together produce which numbers). In relation to auditory interactivity, the mental interactivity is also cognitive, since cognitive activity is required to process the sounds I hear. In relation to somatic interactivity, the mental interactivity is again cognitive. However, the cognitive skills required are somewhat different. Even though memory is also required here, for instance, the task is different (i.e. remembering where the numbers are located on the keyboard).

The motor interactivity linked to all sensory interactivity sub-dimensions is fine motor. In relation to visual, auditory and somatic interactivity, I engage in finger and hand movements based on the sensory feedback I get (e.g. the images I see on screen, the sound from typing on the keyboard, and the feeling of the keyboard buttons). The spatial interactivity linked to both visual-motor and somatic-motor interactivity is both real-life and virtual. This because I interact with both objects in real-life (i.e. keyboard and computer screen), as well as people and objects in virtual space (i.e. the people, images and text in Mathletics). The spatial interactivity linked to auditory-motor interactivity is real-life only because the only sound I hear is from the tapping of the keys on the keyboard; the World Challenge does not have any sound. The media interactivity is digital, since digital media (an Apple Macbook Air laptop) is being used in this instance.

There is many-to-many social interactivity, but only in relation to the visual-motor-virtual-digital interactivity. Although I can see the other learners—in the form of the profile images and personal information (name, country, school)—and they can see me, I cannot chat to them, either via text messages or speech, nor can I touch them, virtually or in real-life. All I can do is compete with them in solving math problems. Despite this, the limited interaction is enjoyable, primarily because I am able to compete with many other learners at the same time, and vice versa. With the exception of this form of interaction, Live Mathletics is a solo activity, especially in terms of auditory and somatic interactivity. This is because I am not interacting with others in real life, and the only way I am interacting with others is using my visual sense in a virtual space (i.e. I can see their names, schools/locations, and how many questions they have answered, but only on screen).

LES 3A and LES 3B: *Minecraft*: Individual player, playing alone in a local game

Minecraft allows for several different play options, but only two of these will be examined here. These are referred to as Learning Experience Scenario 3A (LES 3A) and Learning Experience Scenario 3B (LES 3B).

Description of Learning Experience Scenarios 3A and 3B

Learning Experience Scenario 3A (LES 3A)

In LES 3A, I am playing the *Minecraft* Pocket Edition (or *Minecraft* PE) alone both in real-life and in the *Minecraft* game world (i.e. I am sitting alone and no other characters in the game are controlled by real-life people). The device used here is an iPad. There are no other physical controllers being used other than the iPad's touchscreen, since the buttons used for gameplay are shown on the touchscreen of the iPad (see Figure 66 for a sample screenshot).

Upon entering *Minecraft* PE, I can choose to create a new world or play in an existing world. If I create a new world, I have the option of two Game Modes: Survival or Creative. In Survival mode, only limited tools and resources are provided to me at the start. In other words, I need to acquire additional tools and resources upon entering the world. Survival mode also means I can be attacked by non-player characters (NPCs) that might potentially kill me. In

Figure 66: Screenshot of Minecraft on iPad

Minecraft, these NPCs are called hostile mobs[128] or monsters, and come in a variety of types (e.g. Creepers, Zombies, etc.). In Creative mode, I am given an extensive range of tools and resources at the start. There is no danger of injury because there are no hostile mobs in Creative mode. Creative mode also allows me to fly and do other "cool stuff" (according to the description provided in *Minecraft* PE). In LES 3A, I will be using Creative mode.

When creating a new world in Creative mode, I am given the option of naming the world. This allows me to create multiple worlds that can be revisited later on. Once I create my new world in Creative mode, I can either wander around exploring or start building things. Since the Creative mode already comes with many items in the inventory, I have no real need to go out and mine for materials (unlike in Survival mode); I can concentrate on building or exploring instead.

Learning Experience Scenario 3B (LES 3B)

In LES 3B, I am playing *Minecraft* together with another player, both in real-life and in the *Minecraft* game world (i.e. we are seated next to each other on the couch and we each have a character in the same *Minecraft* world). The device used here is the Xbox One, which requires the use of a handheld controller (pictured in Figure 688). The Xbox One version of *Minecraft* is

[128] The term 'hostile mobs' is used refer to the moving game entities in *Minecraft* that will chase or attack players. 'Mob' is gaming jargon and is an abbreviation of 'mobile'.

Figure 67: Xbox One controller

different from the *Minecraft* Pocket Edition on the iPad in that it has more features. However, both versions of *Minecraft* offer a choice between the same two Game Modes: Survival or Creative. In LES 3B, I will be playing in Survival mode, where only limited resources are provided to me at the start. This means I need to acquire additional resources and tools upon entering the world. It also means I can be killed. Since I am not provided with many resources in Survival mode, part of the game play involves mining for materials in order to build more elaborate buildings and tools. At the same time, I need to be wary of hostile mobs.

Application of model to Learning Experience Scenario 3A

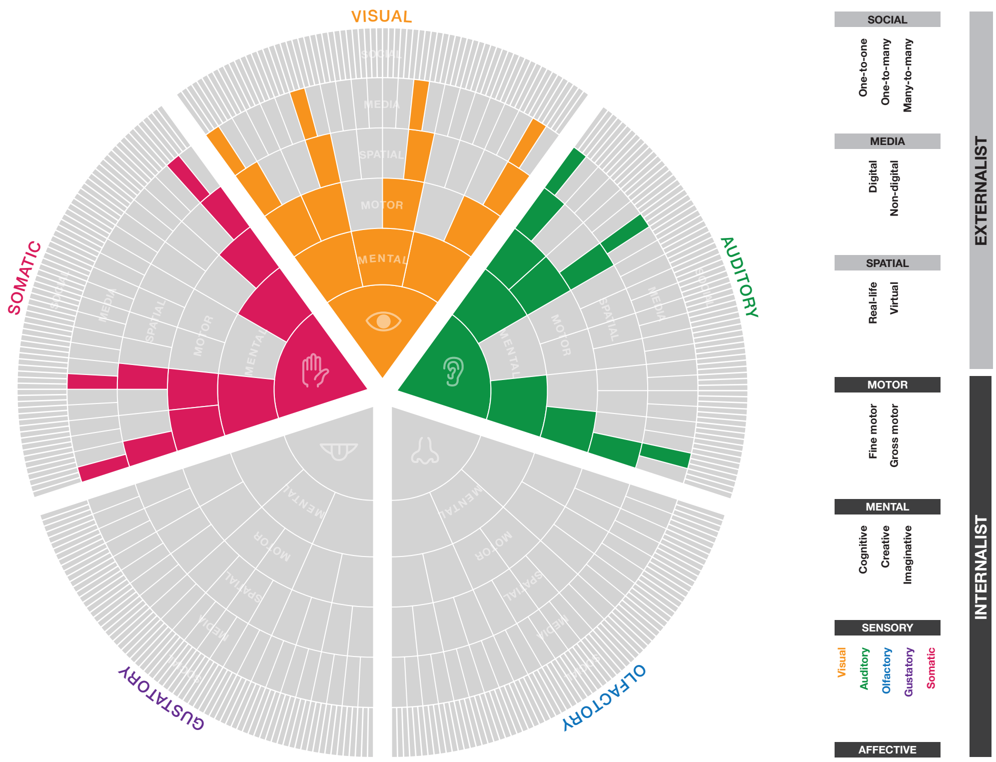


Figure 68: Applying the model of interactivity to LES 3A

Figure 679 shows the model as applied to the LES 3A scenario. As with LES 2, three sensory interactivity sub-dimensions are present: visual interactivity, auditory interactivity, and somatic interactivity. Visual interactivity is present because I have to look at the images, buttons, and text on the iPad screen. Auditory interactivity is present because the sounds produced by the game provide audio feedback when I am using the virtual on-screen buttons, and they also give clues as to the surroundings (e.g. the presence of water or other animals). Somatic interactivity is present because I use my sense of touch to interact with the iPad screen.

The visual-mental interactivity (i.e. mental interactivity in relation to visual interactivity) is cognitive, creative, and imaginative. Cognitive interactivity is present because cognitive skills are needed to remember how the game works and to use the iPad, for example. Creative interactivity is present because *Minecraft* requires me to come up with building designs from scratch. Imaginative interactivity is present because I first imagine how the building might look before I start building it. The motor interactivity linked to the cognitive interactivity sub-dimension is both fine motor and gross motor. The fine motor interactivity occurs in real-life (the movement of my fingers when using the game controller), while the gross motor interactivity occurs in a virtual space (the avatar's movements are limited to gross motor movements within the game). In relation to creative and imaginative interactivity, however, the motor interactivity is gross motor only; I am only using gross motor movement in the game to create buildings and I am imagining only the gross motor movement because the game characters are not capable of fine motor movement. All of the spatial (real-life and virtual) interactivity is linked to digital media interactivity.

The auditory-mental interactivity is cognitive and imaginative. Since I get real-life auditory feedback from tapping the screen helps me to figure out how to respond, the interactivity is auditory-cognitive-fine motor-real-life-digital. At the same time, I also hear the sounds occurring within the virtual world of the game, and these sounds relate to gross motor movement. Thus, there is also interactivity that is auditory-cognitive-gross motor-virtual-digital. The visual and auditory data I am receiving helps to promote my ability to imagine myself performing actions within the game, so there is arguably interactivity that is auditory-imaginative-gross motor-virtual-digital.

The same can be said for somatic interactivity as for auditory interactivity. I get real-life somatic feedback from tapping the screen and using the game controller. This involves cognitive interactivity. Cognitive interactivity is also present when I engage in virtual somatic gross motor-related activity within the *Minecraft* virtual world (e.g. when my avatar picks up and drops objects). As this is happening, I am also imagining the sensation of performing these actions in the game[129]. Thus, the mapping of the interactivity in the somatic interactivity segment is the same as that in the auditory interactivity segment. There is no social interactivity present for any of the sensory interactivity sub-dimensions because I am playing the game alone in real-life and as a single-player.

Application of model to Learning Experience Scenario 3B

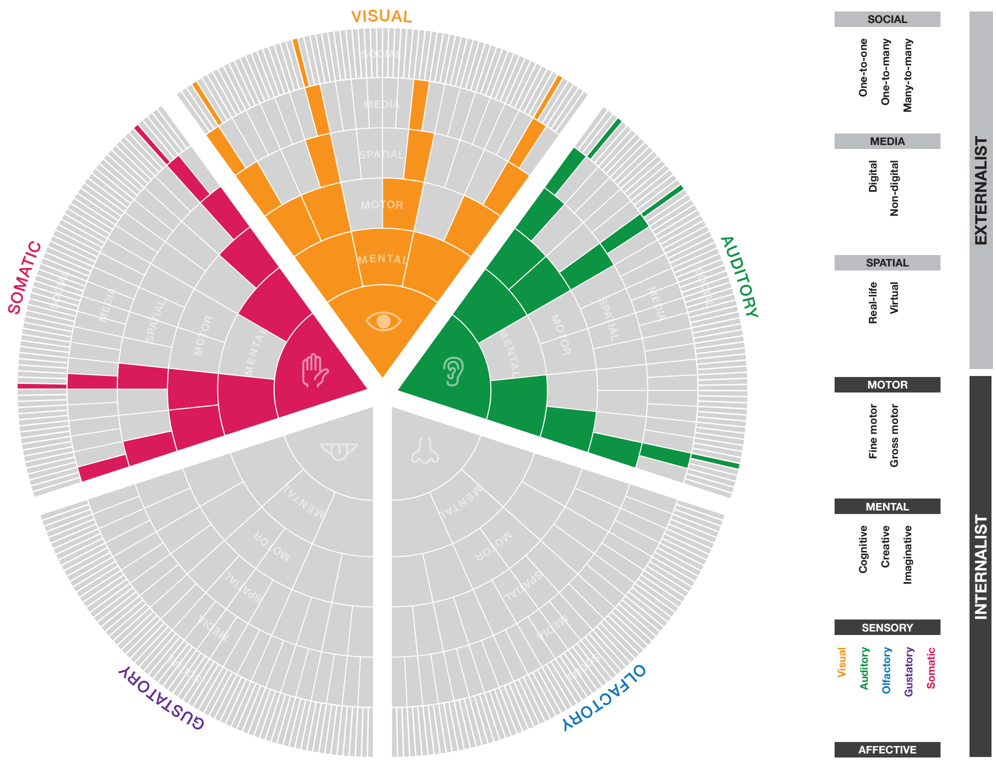


Figure 69: Applying the model of interactivity to LES 3B

Figure 69 shows the model as applied to the LES 3B scenario. There are only minor differences between the model of LES 3A and LES 3B. These differences are found in the social interactivity dimension. In relation to cognitive-gross motor-virtual-digital media streams in visual, auditory, and somatic interactivity, one-to-one social interactivity was coloured. This is because I am seeing, hearing, and touching my friend's avatar in the virtual *Minecraft* world. However, in real life, I am only seeing and hearing my friend without the use of media, and

[129] Here I have to admit that the imagined sense of bopping objects with a hammer or pickaxe—in a Whack-a-Mole manner—is both amusing and satisfying.

this relates to my friend's fine motor movement (e.g. his use of the game controller). Thus, the one-to-one social interactivity segments relating to the cognitive-fine motor-real-life-(no digital media) streams of visual and auditory interactivity are coloured in. The non-digital media segment is not coloured in as no media was used. With regard to imaginative interactivity, however, I am imagining seeing, hearing, and touching my friend inside the virtual *Minecraft* world, so the one-to-one social interactivity segments linked to the imaginative-gross motor-virtual-digital streams in visual, auditory, and somatic interactivity are all coloured in.

Evaluation of the model of interactivity

This evaluation of the model of interactivity is largely summarised. Here a brief outline of the successful aspects of the model and the issues relating to the model are presented. A more detailed discussion of the model and the Learning Experience Scenarios can be found in Chapter 8. In this paragraph, the focus is on evaluating how successful the final model is following its application to the nine testing scenarios and the Learning Experience Scenarios in this section. Having used the model in both these contexts, it was apparent that the model is versatile enough to map a range of very different experiences. The separation of the sensory interactivity sub-dimensions into pie-shaped segments made it easier to distinguish between the sub-dimensions related to each sensory interactivity sub-dimension. The removal of the affective dimension was helpful in reducing the complexity of the model. At the same time, the addition of the name of each interactivity dimension to each ring and the key on the right of the model improved the clarity of the model and made it easier to decipher. The method of shading in colour was fairly easy to understand and use with each of the different experiences.

At the same time, some aspects of the model can be improved. One issue relates to the division of the dimensions and sub-dimensions. It is believed that critique from other researchers and users of the model would be beneficial in establishing whether the current division is ideal, or whether additional adjustments need to be made. Another issue relates to the dimensionality of the model. The two-dimensional format of the model is somewhat limiting, and it may be that a three-dimensional format is be more suitable. This could be explored in future research.

"Human experience in virtual environments and games are made of the same elements that all other experiences consist of, and the gameplay experience can be defined as an ensemble made up of the player's sensations, thoughts, feelings, actions, and meaning-making in a gameplay setting."

(Ermi and Mäyrä 2007, 37)

08

DISCUSSION AND RECOMMENDATIONS

Discussion on the model of interactivity

The discussion on the model is divided into two main focus areas: the design of the model and the potential impacts of the model. Discussion on the design of the model includes general comments about the model's design and its parallels with existing work, followed by more detailed comments on the dimensions and sub-dimensions contained within the model. The discussion on the potential impacts of the model examines how it might change perspectives of literacy and the impact of the model's ability to allow the perceived interactivity in experiences to be explicitly shown and compared.

The design of the model

General comments

The two main positive attributes of the model of interactivity are: the use of a segmented circular model and the use of colour. The use of a segmented circular model is an effective method of visually representating all the interactivity present in an experience. This is because it combines multiple linear flowcharts (similar to the one in Figure 60) into a single diagram. The circular format is also able to clearly show the dimensions of interactivity that are present as well as the relationships between the different dimensions. The use of colour in the model is also effective because the different hues used in the model make it easy to determine which sensory modes the dimensions and sub-dimensions relate to.

However, there are also two main issues. First of all, the model of interactivity is clearly quite complex. Even so, it is still relatively simplistic given the complexity of the interactivity that is actually occurring during an experience. Secondly, it uses a nominal scale that merely indicates whether interactivity is present (in the form of a Yes-No scale), instead of an ordinal or interval scale that can indicate the level of interactivity present. The addition of an ordinal or interval scale to the model of interactivity will be investigated in future research.

Parallels with existing work

Some of the internalist interactivity and externalist interactivity dimensions partly overlap with Norman's (2013) three levels of emotional design and the four threads of experience proposed by Wright, McCarthy and Meekison (2005). Norman's three levels of emotional design are: visceral, behavioural, and reflective. The visceral level relates to the sensory interactivity dimension, the behavioural level to the motor interactivity dimension, and the reflective level to the mental interactivity dimension. Since Norman suggested that the three levels combine to generate an emotional response, it can be said that the emotions resulting from the three levels collectively relate to affective interactivity. Norman's three levels did not take into account the media, spatial and social aspects of designs.

Wright, McCarthy and Meekison's four threads of experience are: compositional, sensual, emotional, and spatio-temporal. The sensual and emotional threads relate to the sensory interactivity and affective interactivity dimensions. The spatio-temporal thread partly relates to the spatial interactivity dimension, however the temporal aspect is absent in the model. Their research noted that when the four threads of experience were used by the consultants Siegelgale UK in an evaluation exercise, Siegelgale found that three out of four threads of experience were sufficient to articulate the user experience, namely the compositional, sensual, and emotional threads. They also "suggested that a concept of physicality or embodiment seemed to be lacking"; there was no capacity "to capture the similarities and differences between on-line and offline, between actually physically handling objects and reading about their descriptions" (46-48).

The issues pointed out by Siegelgale are actually addressed in the final model of interactivity, due to the inclusion of the spatial interactivity, media interactivity, mental interactivity, motor interactivity, and sensory interactivity dimensions. This is testament to the strength of the model of interactivity, and suggests that it has potential as a tool for analysing and deconstructing users' experiences. Interestingly, the spatial, media, and social interactivity dimensions also parallel the live (real people, real system), virtual (real people, simulated system) and, to some extent, constructed (simulated people, simulated system) experiences described by Gagné et al. (2005, 226).

Comments on the dimensions and sub-dimensions of interactivity

As not all of the dimensions and sub-dimensions of interactivity are worth discussing in detail, only the ones of particular interest will be examined here. These include the affective interactivity dimension, the somatic interactivity sub-dimension, the cognitive interactivity sub-dimension, the spatial interactivity dimension, and the social interactivity dimension.

Affective interactivity

Affective interactivity was removed from the model of interactivity in this version as the high level of complexity of affect means that it is better served by being in a separate, stand-alone model (similar to Plutchik's wheel of emotions) that can be used together with the model of interactivity. The development of this requires further research.

Somatic interactivity

Dividing somatic interactivity further into another level of sub-dimensions was considered, but a major concern was that it would overcomplicate the model. Determining how to do so was also difficult given that the somatic senses can be classified in more than one way. Hall and Guyton (2016) contained two different methods of classifying somatic sensations, either as three physiological types—mechanoreceptive[130] somatic senses, thermoreceptive senses, and pain senses—or as the following four types: exteroreceptive or proprioceptive, visceral, or deep. (607)

Cognitive interactivity

To maintain the simplicity of the final model at this time, cognitive interactivity was not divided into sub-dimensions. However, it is recognised that a variety of cognitive skills are used during cognitive interactivity and these very likely determine the nature of the cognitive interactivity that occurs. Therefore, it is worth considering the integration of frameworks such as Bloom's Taxonomy[131] into future versions of the model.

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130 The mechanoreceptive somatic senses can be further divided into mechanoreceptive tactile senses (these include touch, pressure, vibration, and tickle senses) and mechanoreceptive position senses (these include static position and rate of movement senses).

131 Bloom's Taxomony is the common name for one of the most popular frameworks that outline the abovementioned cognitive skills. The use of Bloom's Taxonomy is widespread amongst those in education (Wineburg and Schneider 2010). The original Taxonomy was published under the title *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain* (Krathwohl 2010).

Creative interactivity

In the model, creative interactivity relates to the production of creative outputs rather than simply the creation of outputs. As such, creative interactivity is seen as relating more to creativity than to cognitive ability. Others have also made a distinction between creativity and cognitive ability. Eysenck (1983) proposed that creativity is linked to personality rather than cognitive ability. Batey and Furnham (2006) observed that although "early investigations into the relation between creativity and intelligence suggested that the two concepts are not the same", over a century later "investigators still hold there to be some form of a dichotomy between IQ and creativity". However, the relationship between intelligence (i.e. IQ) and creativity has still not been clearly "mapped and explained". (Batey and Furnham 2006)

Spatial interactivity

The combination of 3D graphics, surround sound, together with somatic and motor interactivity, while using a digital device more or less represents the virtual reality gaming experience that current consumer technology is capable of offering (i.e. virtual reality headsets such as the Oculus Rift, Sony Morpheus, etc.). A proposed add-on to existing virtual reality headsets, the FeelReal virtual reality mask, aims to expand on the virtual reality experience by allowing the inclusion of smell and enabling the simulation of "wind, heat, water mist and vibration", according to the product website (see www.feelreal.com).

The problem is that the model of interactivity does not clearly reflect this. Although it differentiates between real-world and virtual spaces, it does not provide a means of differentiating between virtual spaces that are two-dimensional (2D) and three-dimensional (3D). Additional investigation into dimensionality indicated that spatial interactivity was best suited to locate dimensionality because it is a spatial quality—Adams (2009) classified dimensionality as spatial and identified four types of spatial dimensionality to be considered when designing game worlds: 2D, 2.5D, 3D and 4D. Adding dimensionality to the model of interactivity would make it possible to differentiate between interactivity that takes place in virtual 2D, 2.5D, and 3D spaces, as well as in real-life 2D (e.g. paintings, photographs) and 3D spaces (e.g. buildings). However, this was not done in the final version of the model due to concerns that it would overcomplicate the model.

Social interactivity

The model only mapped social interactivity with a real person. However, in hindsight, it is possible to argue that social interactivity is present even if the people are not real, such as in a dream. Unlike with a video game, the dreamer is not aware that the people in the dream are not real (except upon waking), so the social interactivity experienced by the dreamer feels real. This begs the question: should the model differentiate between social interactivity with real people (whether in real life or in the form of player characters in video games) and social interactivity with non-player characters (NPCs)? After all, there is research that suggests people do treat digital devices as human (Reeves and Nass 1996). Also, the final model does not map social interactivity involving animals. It is suggested that this be looked at in subsequent research.

Potential impacts of the model of interactivity

There are two main impacts of the model of interactivity: (1) it can be used to challenge existing interpretations of literacy; (2) it can be used to compare perceived interactivity.

Provide a new perspective on literacy

The model of interactivity can be used to challenge existing interpretations of literacy. The literature review showed that current perspectives tend to view literacy as referring to the ability to both interpret as well as create—in the case of written literacy this is understood to mean reading and writing, and in visual literacy this can be taken to mean understanding and creating visual material. The question, as Brumberger (2011) noted in relation to visual literacy, is whether it is necessary to be able to both create and interpret visual material in order to be considered visually literate. After all, if we insist that a person must be able to do both to be considered visually literate, this would significantly reduce the proportion of visually literate people. However, this does not mean the criteria for visual literacy should be reduced, but rather that clearer distinctions need to be made between different aspects of literacy—such as, the ability to produce visual material, the ability to navigate and use visual material, the ability to engage in higher order criticism and analysis of visual material, and the ability to understand visual material. The same can be said for written literacy, and indeed, any form of literacy.

At the moment, the terminology relating to literacy that currently exists does not adequately differentiate between the ability to interpret and the ability to create. The ability to produce visual material could be called creative visual literacy. Functional visual literacy can be used to refer to the ability to navigate and use visual material, while critical visual literacy can be used to refer to the ability to engage in higher order criticism and analysis of visual material[132]. Finally, the ability to understand visual material could be called comprehensive visual literacy.

Additionally, we should also consider the issue observed by Avgerinou and Ericson (1997, 281)—that there was no differentiation between visual stimuli that are “non-arbitrary, iconic and representational” (i.e. images) and those that are “arbitrary, digital and non-representational” (i.e. written text). In the broader context of literacy, this issue demonstrates that the existing way literacies are identified and named is problematic. The emergence of recent ‘new’ literacies largely appears to have been reflexive reactions to the widespread adoption of forms of technology (e.g. technology literacy, media literacy), rather than a planned effort at deconstructing literacy and how it relates to education in a contemporary context.

Given this, a more methodical approach to identifying and naming literacy types may be more appropriate. Here is where the model of interactivity and its dimensions can be used—to examine and deconstruct literacy. Based on the model of interactivity, other proposed literacy types (in addition to visual literacy) could include auditory literacy, somatic literacy, gustatory literacy, olfactory literacy, fine-motor literacy, gross-motor literacy, media literacy, social literacy.

Comparing perceived interactivity

The model of interactivity can be used to compare both an individual’s perceived interactivity of two or more experiences, and the perceived interactivity of the same experience across two or more different individuals. Being able to simultaneously view and compare the interactivity in different experiences, or across different individuals, is one of the most valuable functions of the model of interactivity, in addition to being able to identify the various interactivity dimensions and sub-dimensions in an individual learning experience.

Figure 70 shows how the model can be used to display the interactivity across a range of learning experiences at a glance; it shows all the LES models from Chapter 6 (from the top left in a clockwise direction, they are LES 1, LES 2, LES 3B, and LES 3A respectively). Viewed like this, it is clear that the amount of interactivity present is highest in LES 3B, followed by LES 3A, then LES 2, and lastly LES 1.

[132] These names are based on the concepts of functional literacy and critical literacy proposed by Buckingham et al. (2005) in the context of media literacy (see page 131).

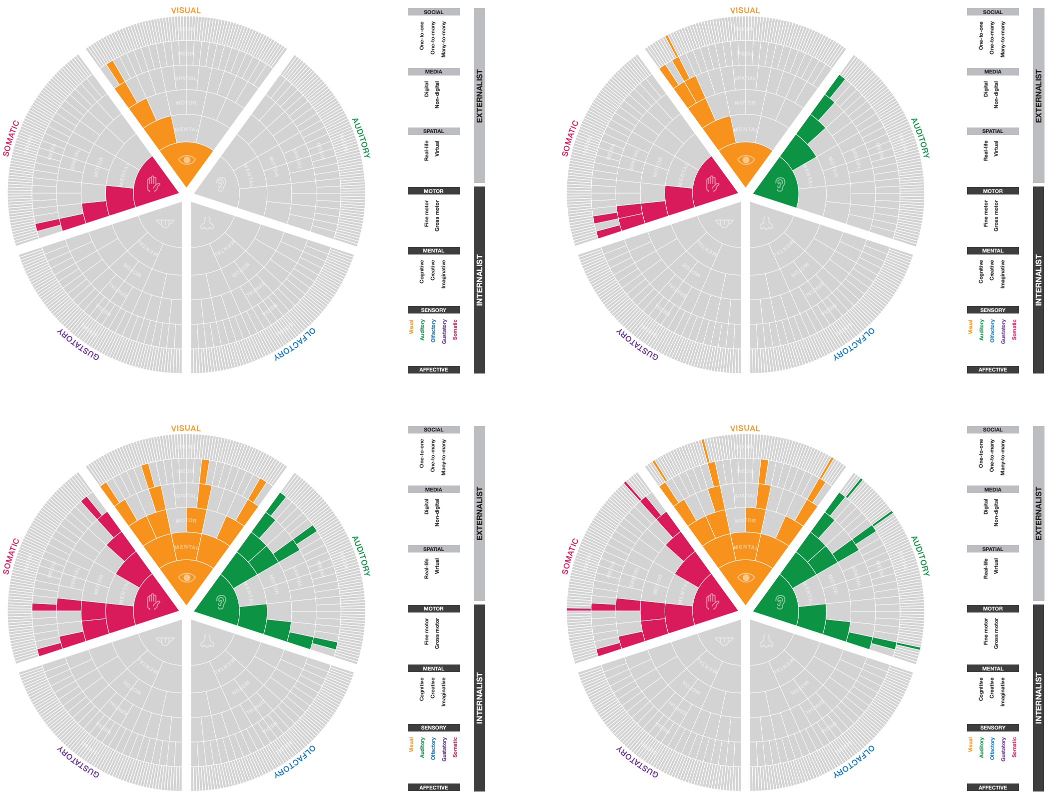

Figure 70: Comparing the Learning Experience Scenario (LES) models (Clockwise from top left: LES 1; LES 2; LES 3B; LES 3A)

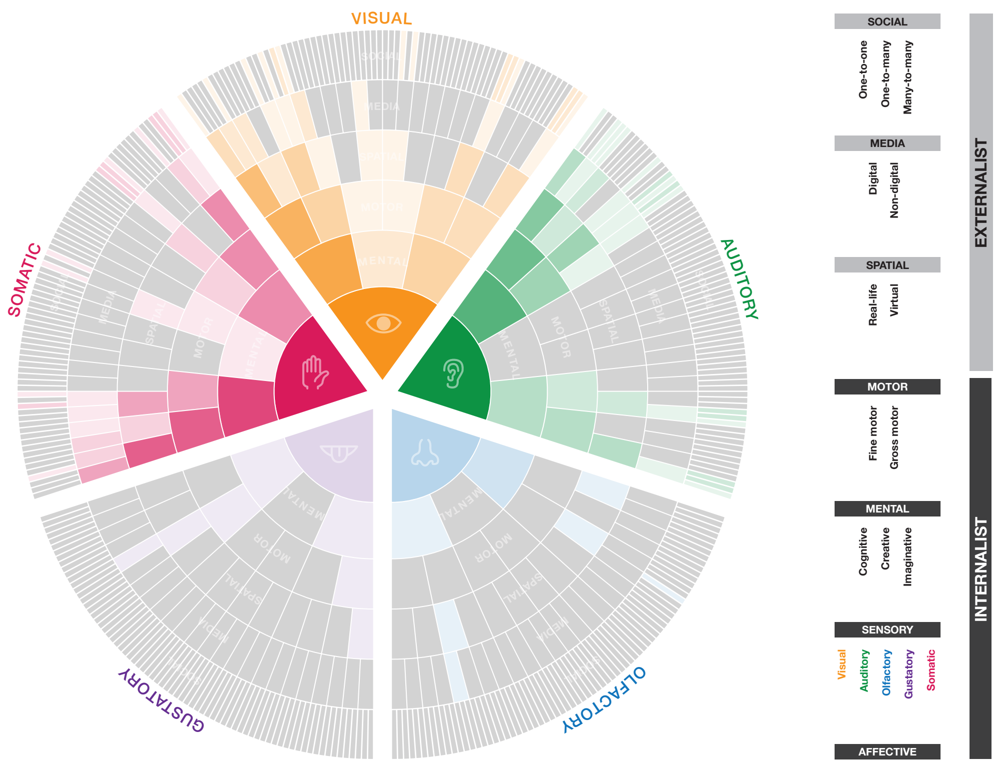

Figure 71: Overview of the interactivity across Scenarios 1 to 9

The model can also help to identify which interactivity dimensions and sub-dimensions are absent from a given set of different learning experiences, as well as the interactivity sub-dimensions that are addressed more frequently. This can be accomplished by layering the models of the different learning experiences on top of each other. Figure 71 shows an example of how this might look. It is constructed by overlaying the models from scenarios 1 to 9. Viewed like this, the models show the interactivity dimensions and sub-dimensions that are most frequently present within the nine different scenarios, as well as the ones that are absent or less frequently present.

Discussion on the Learning Experience Scenarios

Two main observations were made. First, using the model of interactivity with Learning Experience Scenarios (LES) showed that it was able to work with different types of learning experiences. However, given that the number of LES used was rather limited, more testing is required to properly ascertain its versatility. The second (and more significant) observation was made while viewing the models of the different Learning Experience Scenarios side-by-side in Figure 70. From this, it was clear that the interactivity occurring in each of the three Learning Experience Scenarios was markedly different. One of the key thoughts arising from this concerns the concept of mental load. Mental load is used alternatively to refer to both “the objective workload imposed by the task (e.g., event rate)” and “the subjective ratings of the operator with regard to the demands of the task” which can include emotional and physical aspects (Gaillard 1993, 991). It is concerned with the relationship between “the processing that is required to perform the task” and the capacity of the individual to do this (992).

Here the potential issue is that the presence of more interactivity sub-dimensions may not only indicate that more interactivity is occurring, it may also indicate the presence of a greater mental load. In light of this, it is possible that the presence of more interactivity sub-dimensions can actually be detrimental in certain contexts. For instance, this might be problematic when a learner is required to learn something particularly difficult, since the mental load required to learn a difficult new concept is likely to be greater than the mental load required to learn a new concept that is simple or somewhat familiar. So, if the learner has to deal with the mental load resulting from too much interactivity, he or she may find it difficult to learn or retain a new concept that is difficult.

Therefore, when learning a difficult new mathematical concept, it may be better for the learner to do it on paper, which involves much less interactivity, than to try and learn it while playing *Minecraft*. Conversely, if the intention is for the learner to practise and apply a particular concept, then doing so using *Minecraft* might be a more engaging and enjoyable experience.

Recommendations relating to the model of interactivity

Uses for the model of interactivity

Since the model can be used map both potential (intended and unintended) and actual perceived interactivity of an individual, it can be used to map different individuals' perceived interactivity of the same experience. This would be significant value, since Steuer (1992, 80) emphasised that "the relative contribution of each of these dimensions[133] to creating a sense of environmental presence will vary across individuals". The ability to map different individuals' perceived interactivity of the same experience would thus allow one individual's experience to be compared with another's. This also means that different individuals' perceived interactivity can be compared with the designer's intended potential interactivity to determine if the experience is occurring as planned, and identify any discrepancies between the intended potential interactivity and the actual perceived interactivity of an experience.

Using the model of interactivity to map an individual's perceived interactivity in two or more different experiences can also be useful. By comparing the maps of the different experiences, one can identify similarities and differences between the experiences, and also highlight any issues relating to interactivity so that problem-solving can focus on these areas.

Possible changes to the model of interactivity

For ease of reading, the possible changes to the model are summarised as a series of bullet points. These proposed changes are derived from the discussion of the final model and the

[133] The dimensions referred to here are vividness and interactivity.

issues identified in "Evaluation of Version 4" on page 264 that were not addressed in the final model.

- » Consider whether it is necessary to include or address other modes of sensory perception (see Jarrett 2014) in addition to the five basic senses;
- » Consider whether it is necessary to divide the somatic interactivity sub-dimension further into another level of sub-dimensions;
- » Consider whether it is necessary to integrate Bloom's Taxonomy or other frameworks into cognitive interactivity sub-dimension;
- » Consider how the model can show differences in dimensionality, so that it can differentiate between 2-dimensional (2D), 2.5-dimensional (2.5D), and 3-dimensional (3D) experiences;
- » Consider how the model can show differences between social interactivity with real people (whether in real life or in the form of player characters in video games) and social interactivity with non-player characters (NPCs);
- » Consider how the model can show social interactivity with animals;
- » Consider whether it is necessary to depict characteristics such as consciousness (i.e. is the interactivity occurring consciously or subconsciously) in the model and how this might be done;
- » Consider whether it is necessary to depict the quality of the various sensory interactivity sub-dimensions (e.g. high quality visual, low quality audio, etc.) in the model and how this might be done;
- » Consider whether it is necessary to depict time (i.e. is the interactivity synchronous or asynchronous) in the model and how this might be done[134]; and
- » Consider whether the model should be three-dimensional instead of two-dimensional and how this might be accomplished.

Recommendations for further research

As stated above, the changes that have been listed are simply possibilities. It is still too early to make definitive or concrete recommendations. Further research needs to be conducted to determine if these changes are necessary, by engaging in more extensive testing on additional scenarios, as well as testing with groups of real users, experience designers, and instructional designers. As noted in "Affective interactivity" on page 302, additional research also is required to develop a separate stand-alone model of affective interactivity that can be used in

[134] If a temporal dimension is introduced, the works of Wensveen, Djajadiningrat and Overbeeke (2004) and Vallgårda (2014) may be useful.

conjunction with the model of interactivity. Having these two models can make it easier to determine whether particular combinations of interactivity in experiences produce specific emotions, and possibly even identify what these combinations might be.

In educational contexts, the model of interactivity can be used to analyse learning experiences in order to determine whether particular combinations of interactivity promote learning, as well as whether particular combinations of interactivity are more suited to some forms of learning than others. This would be valuable since, as Woo and Reeves (2007) noted, "every interaction in a Web-based learning environment does not have an influence on increased learning" (16), but little is know about how and why this is so.

There are many other potential research avenues for the model of interactivity in other disciplines. Here are a few examples: the model of interactivity could be used in neuroscientific research to observe the relationship between the different interactivity occurring during an experience and the related brain activity; it could also be used to inform the development of artificial intelligence because it shows the level of complexity required for artificial intelligence to mimic that of humans; in a media context, it could be used to plan and design for more immersive cinematic experiences; finally, the model can also be used to provoke us to think about the balance between real-world and virtual experiences we, as humans, currently have versus what we should have in order to live more consciously with the technologies we create and use every day.

09

CONCLUSION

Conclusion

> "...we are participants in an unfinished universe rather than spectators of a finished universe."
>
> (Garrison 1994, 8, emphasis in the original)

My protracted journey from the start of this research to its present conclusion has made one thing clear to me—and that is how little we know about how human beings work, despite everything we already know. One limitation we have to fight against is the fact that it is difficult to see what is all around us because what is normal to us is often invisible to us, in much the same way that the fish in David Foster Wallace's parable[135] do not notice the water in which they swim. Put in the context of this research, if we are the fish, then interactivity is the water in which we swim.

The quote by Garrison at the top of this page alludes to this, as does his observation about John Dewey: "As Dewey understood it, in order for individual organisms or entire species to survive and exalt their existence, they must carry out successful transactions with the environment." (Garrison 1994, 8) Participating in the world involves interactivity, as does carrying out transactions with the environment. This constant interactivity produces constant change. It is no wonder our brains are plastic. Maybe neuroplasticity is one way we have adapted to deal with the constant interactivity we engage in. "Every time we acquire a new skill," wrote Naughton (2012), "groups of neurons in the brain create new connections and pathways among themselves. So our brains have what computer scientists might call an open architecture—one that is versatile enough to reconfigure itself in response to changing

[135] See the parable reproduced at https://www.newyorker.com/books/page-turner/this-is-water.

circumstances." (24) This versatility is reflected in and is central to the model of interactivity; in other words, the model of interactivity needed to be versatile in order to deal with the unpredictable nature of experience, and its propensity to change.

Another important thing that the model of interactivity revealed was not only the extent of the complexity of our interactions with the world around us, but also the complexity of our inner world—our minds and our emotions. This realisation has led me to make some interesting (and perhaps outrageous) conclusions. Mapping experiences using the model of interactivity made it clear to me that we are still a long way off from creating artificial intelligence that is indistinguishable from human intelligence, because our current technologies are still primarily visual and auditory, although they are becoming more tactile with the introduction of haptic feedback in touchscreen technologies. I believe that until we are able to develop the processing power and ability to digitise other sensory modes (e.g. gustatory and olfactory) and affect, there will be significant limits to how human-like artificial intelligence can be. These limitations also applys to the pursuit to create a virtual reality that is indistinguishable from the real world, and I do not believe this will be possible until we develop technologies that can interpret and create gustatory and olfactory outputs.

These are some of the more tangential thoughts I have had as a result of this research. On a more practical level, the model of interactivity has immediate applications to the design of learning experiences. As mentioned in this discussion on page 306 and page 306, the model can be used to compare different learners' perceived interactivity of a learning experience, to determine whether a learning experience designer's intended interactivity of an experience parallels the learners' perceived interactivity of the experience, and to generate a longitudinal plan of learning experiences such that they involve the required range of interactivity dimensions and sub-dimensions.

Regardless of how it ends up being used, I believe that the model of interactivity offers a novel and useful method of viewing and understanding interactivity as well as experience. It is my hope that it will provoke more interest in the study of interactivity and, at the very least, help to improve the development of learning experiences for current and future generations of learners of all ages.

"Technology must be integrated into the schools as it is integrated into our lives, but with this inclusion, lessons must be taught and questions asked not only about the remarkable ways technology transforms our world, our society, and our lives, but also about what technology does to us and how we interact with each other when balancing technology and human interaction."

(Davis 2012, 18)

10

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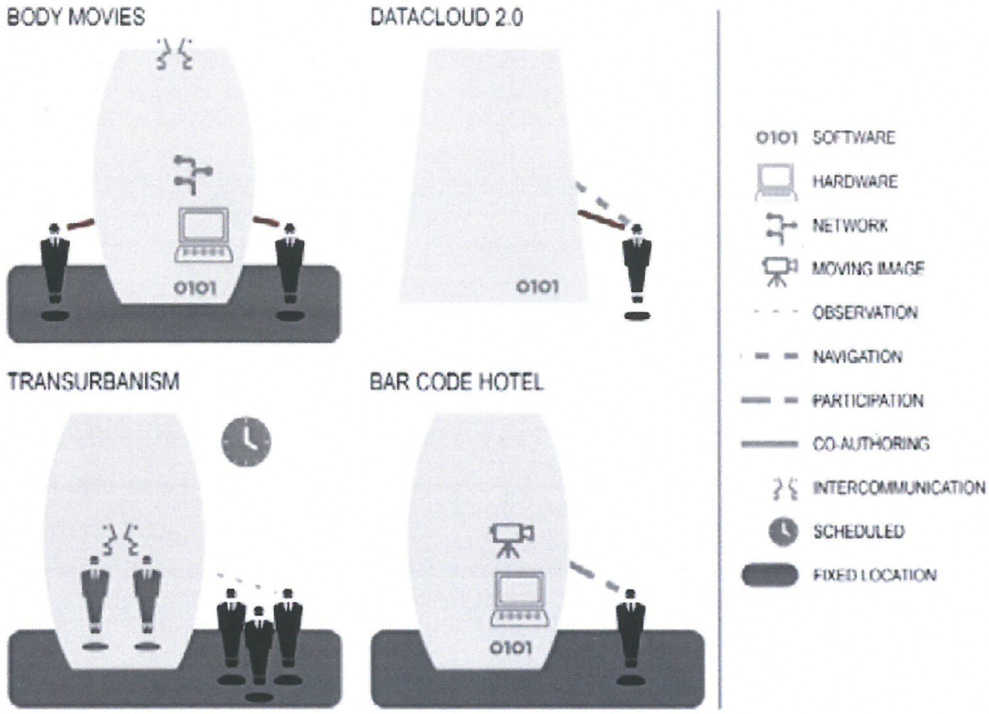

The above image showing schematic representations of types of interaction found on page 20 of:

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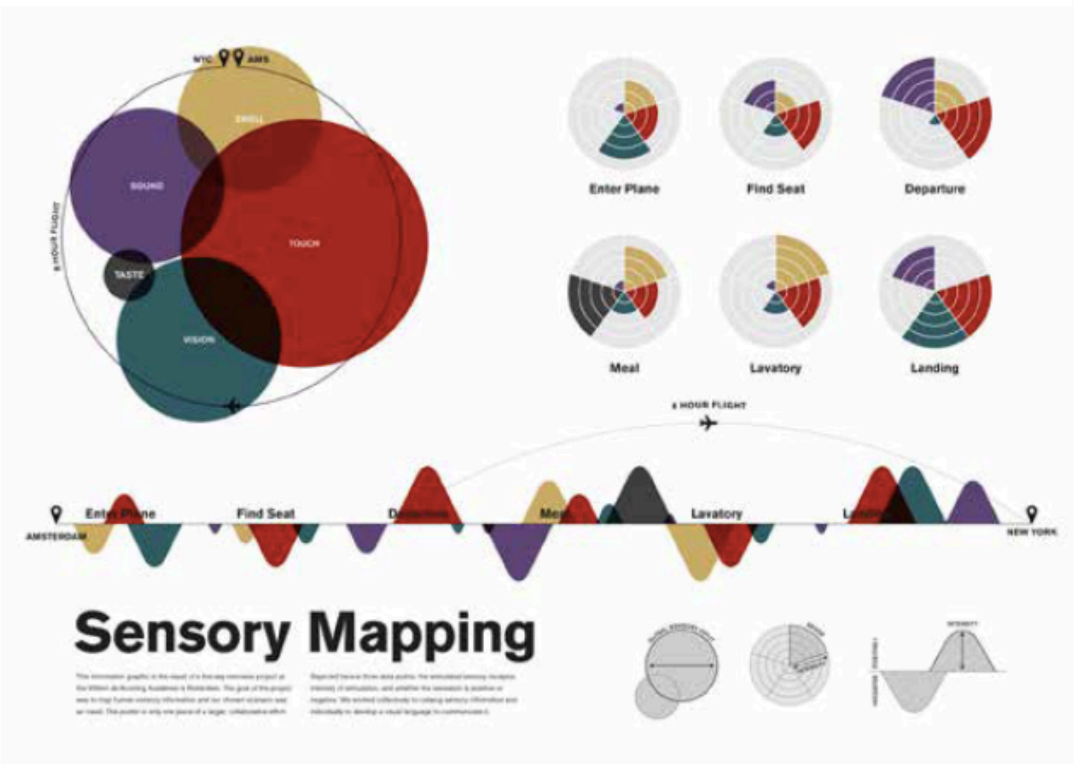

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To: Jo Li Tay
Re: Use of your sensory mapping infographic in my PhD

14 March 2018 8:00 am
Inbox - Curtin

CD

Hi Jo Li,

Thanks for the email. You are welcome to use the image! Happy to sign something over Docusign or some other digital signing tool.

Colin

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>
> I am writing to request permission to use your infographic in my PhD. Please view the attached PDF for details.
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> Thank you for your time, I look forward to hearing from you soon!
>
> Cheers,
> Jo Li
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