TOWARDS UTOPIA: THE ROLE OF AMBIENT SOUND IN CHILDREN’S TANGIBLE INTERACTION WITH A SUSTAINABILITY TOOL.

by

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THE REQUIREMENTS FOR THE DEGREE OF
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Applied Science

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ABSTRACT

Ambient sound has been advocated as a means for increasing the vividness of multimedia learning materials, but little research has been conducted on the subject. In this study, the Towards Utopia tangible user interface-based learning system was created to facilitate learning of sustainability concepts for 7-10 year-old children. A comparative experiment was conducted with 30 children to investigate if ambient sound enhanced learning and engagement. Half of the children used the Towards Utopia with the ambient sound mode turned on while the remaining children used the system with the ambient sound mode turned off. The experimental results showed no statistically significant difference between groups in measures of learning, enjoyment or perceived competence. However, all children showed a statistically significant increase in learning scores related to basic sustainability concepts.
DEDICATION

Dedicated to Audrey Ryerson, my Mom; she has been my shining light of purpose throughout my education. Her deathbed request was that I get my post-secondary education. Thank-you, Mom!
ACKNOWLEDGEMENTS

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Last but not least, special thanks to my spouse, Cliff Veley for lending his narrated voice to the characters in the Towards Utopia learning system. I also wanted to say a very special thank you for always being there for me; encouraging me, supporting me, putting up with me, and accepting seeing me less often that we both would have liked.
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| Immersion | The state of being immersed; absorbing involvement; extensive exposure to surroundings.  
Merriam-Webster Dictionary (2009)  
Immersion is a metaphorical term derived from the physical experience of being submerged in water. We seek the same feeling from a psychologically immersive experience: the sensation of being surrounded by a completely other reality, as different as water is from air, that takes over all of our attention, our whole perceptual apparatus. Murray (1997) |
| Engagement | Engagement comprises cognitive engagement, which involves attention to the activity and concentration and promotes “useful” learning. Xie, Antle & Motamedi (2008) |
| Intrinsic Motivation | Intrinsic motivation relates to enjoyment, which describes natural inclinations toward spontaneous interest and exploration that are essential to cognitive and social development. Xie (2008) |
| Suspension of Disbelief | Willing suspension of disbelief’ or ‘poetic faith’ that allows us to enjoy the unrealities of art or literature. It involves a combination of psychological, neurological, and aesthetic moves. Murray (1997) |
CHAPTER 1.1 INTRODUCTION

Our society seems to have reached the point where our educational methods no longer adequately address the problems with which we are confronted, and more effective methods must be found (Meadows, Meadows & Randers, 1992). Although it is recognized that sustainability can probably be best promoted in an educational context, (Fuller, 1981, p. 265) such initiatives are still in the earliest planning stages (Learn Canada 2020, 2008). The human race seems to beat a point in history where it is apparent the status quo cannot be maintained much longer (Meadows, Meadows & Randers, 1992), yet we are reluctant to make the necessary changes that will move us toward sustainable resource use, ecological practices and economic policies. We stand at the threshold of the future, but do not venture through because we are afraid of change. We could well destroy our environment, and destroy ourselves. Alternatively, through collective action, we could allow our transformation to be tranquil, emerging with a new outlook and philosophy. I personally believe that, as human beings, we still have a choice. I believe it is up to us, as citizens of our planet, to help guide its trajectory through the necessary transition. However, with the inertia of political stagnation (Baudrillard, 1992), it will be challenging to map our course.

Ambient sound is the background “noise” that makes up our environment, both real and digital. Ambient sound is used as a cinematic technique to suture scenes together. Ambient sound is the background sound that helps increase the vividness, intensity and immersiveness of audio-visual material by making the storyworld more
realistic. As such, ambient sound may have the potential to increase the effectiveness of educational programs intended to improve awareness of sustainability issues and other pro-social concerns.

1.1.1 SUSPENSION OF DISBELIEF

The concept of “willing suspension of disbelief” was coined by Samuel Taylor Coleridge (1817) as part of his analysis of his use of fantastic or non-realistic elements in his fictional literature. Coleridge’s idea was that being able to suspend disbelief made it possible for people to expand their perspective in an enjoyable way, and to open their minds to possibilities they might otherwise not consider. It is important to note that an extension of Coleridge’s original use of the term suspension of disbelief it is often applied in the context of non-fantastic content such as drama. As Murray (1997), in *Hamlet on the Holodeck*, puts it:

"To sum up, we can understand the phenomenon Coleridge described as a ‘willing suspension of disbelief’ or ‘poetic faith’ that allows us to enjoy the unrealities of art or literature. It involves a combination of psychological, neurological, and aesthetic moves. Aesthetically, we give up control to art. … In short, transported by a work of art, we can believe even in Spider-Man. And, believing in Spider-Man, we are transported even as he is (so to speak). (Murray, p. 319)"

Chris Dede (2009) says it this way:

"When you are immersed in something there’s a strong subjective feeling that you are having some kind of experience that’s really comprehensive and realistic. (Science Magazine Podcast)."
In his paper, *Immersive Interfaces for Engagement and Learning*, Dede (2009) speaks of immersion, suspension of disbelief, engagement and learning. Dede argues that the more design strategies emphasize actional, symbolic, and sensory factors, the greater will be the participants’ “suspension of disbelief.” He states that digital immersion can enhance learning by allowing multiple perspective situational learning and transfer. Dede maintains that an immersive interface can help with pedagogy by creating a “digital fluency” that promotes engagement and eases transfer from school to real-world applications.

According to Dede, immersion is a subjective experience that gives the impression that the participant is actually participating in a believable experience. In order to induce immersion, sensory, actional, and symbolic factors would be designed into the experience: sensory immersion through haptic space; actional immersion through the haptic experience and symbolic immersion by drawing on a participant’s beliefs, emotions, and values (2009).

The things that we learn create the mind. Egan, K. (2009) SFU readers group.

### 1.1.2 Ambient Sound as a Means of Achieving Engagement

What it is that makes movies in theatres so entertaining and enjoyable? One of the factors is ambient sound. It is worthwhile simply to close your eyes the next time you are watching a movie and listen only to the sound track. Listen only to the background sound— the subtle, almost imperceptible background sounds that lead a movie along its trajectory. These small sounds are ambient
sounds. How can we create a richer learning experience through suspension of disbelief? Ambient sound is claimed to be one of the mechanisms capable of enhancing suspension of disbelief, and thus supports active engagement (Whittington, 2007).

Creating an environment for engagement with educational materials by using ambient sound may well be a useful consideration for multimedia based education. I believe that ambient sound is crucial for suspension of disbelief and may lead the audience to be more engaged in the learning activity. Based on educational theory (Pritchard, 2009, p. 42), engagement is required in order for learning to occur. I propose that ambient sound might offer a possible means for enhancing learning with multimedia materials related to vital social and ecological issues.

1.1.3 MULTIMEDIA LEARNING

The advocates of multimedia learning claim people learn better from words and pictures than from words alone. They say people learn better from both words and pictures because information comes in through two channels, and the information in each channel is processed separately, resulting in a parallel processing mode which is more efficient than single channel processing. In working memory, visual information is held and processed in the “visual-spatial sketchpad” and words and sounds are held and processed in the “articulatory” or “phonological loop” (Baddeley & Hitch, 1974). Effective
multimedia learning results from learning materials that are designed to include both pictures and words to engage both processing channels (Mayer, 2005). I posit that ambient sound will enhance learning outcomes by enriching the pathways in short-term memory by adding auditory content that is not informational and thus enhancing the educational experience. I also posit that since the auditory channel may be less used than the visual channel, there is more room for improvement in this channel, and thus a greater chance of learning gains due to immersion, suspension of disbelief, engagement and enjoyment.

1.2 STATEMENT OF THE PROBLEM

Contemporary education often does not present information about social, ecological and economic challenges with sufficient vividness and concreteness that children are able to appreciate what such concerns are about. (Meadows et al., 1992). In general terms, part of the solution may be to mobilize the most effective technologies available to improve educational practices. The problem is complex and multi-faceted, and addressing the entire matter would be far beyond the scope of this thesis. Only one small facet of the solution will be addressed in this research project. This concerns the proposed use of ambient sound as a means to enhance the immersion, engagement, and enjoyment of a tangible interactive in an educational context.

I propose that ambient sound enhances engagement, which in turn enhances learning. However, it is possible that the addition of ambient sound to
the “words” channel will overload the articulatory loop in working memory since all sound may share this channel or mode of processing. This thesis addresses the question of whether or not the use of ambient sound in a tangible user interface actually increases the effectiveness of educational content.

1.2.1 RESEARCH QUESTION

Suspension of disbelief is an individual experience that is subjective and difficult to measure. Furthermore, in tactile-rich interactive Tangible User Interface (TUI) environments, suspension of disbelief (narrative pleasure) can be associated with more active manifestations of immersive experience, such as constructs like Csikszentmihályi (1990) “flow,” or Murray's (1997) “active creation of belief,” or Emri and Mayra’s (2005) “imaginative immersion.” Suspension of disbelief in conjunction with these related immersive states may make the learning processes more enjoyable and engaging by enhancing affective and cognitive processes (as outlined in Chapter 2).

In this thesis, engagement is used as a surrogate for suspension of disbelief and related immersive states. One measure of engagement is the intrinsic motivation inventory (IMI) which measures participants' engaged interest, enjoyment and competence in an activity based on a model of intrinsic motivation (Plant, R. & Ryan, R. 1985). The research question then becomes, Does ambient sound promote increased engagement in learning? Where engagement
is defined and measured in terms of enjoyment, interest and competence as operationalized by the IMI.

1.2.2 HYPOTHESIS

Ambient sound increases suspension of disbelief, which supports increased children’s engagement with learning materials.

1.2.3 METHODOLOGY

This project addressed the research question using a comparative experimental methodology. The research instrument was an interactive multimedia application designed to support children to learn about sustainability issues. The tangible user interface (TUI) was entitled Towards Utopia, and was created specifically as a research instrument for this research project. To facilitate experimental comparison, the interface had both an ambient sound mode and non-ambient sound mode.

Learning was assessed with pre and post orally administered questionnaires. The goal was to determine whether the children learned more when the ambient sound mode was on than when the non-ambient sound was off.

It is difficult to accurately measure suspension of disbelief since it is not directly observable (i.e. it is a latent variable). It is also difficult to measure children’s engagement. Therefore, for the purposes of this research, engagement was operationalized as enjoyment, and enjoyment was measured by using the intrinsic motivation questionnaire (IMI). This questionnaire elicits self-reports of
enjoyment based on a model of enjoyment which assumes that activities which are intrinsically motivating also enjoyable (Ryan, 2006).

1.3 LIMITATIONS OF THE STUDY

It is important to note that this paper explores very illusive concept related to immersion, engagement and enjoyment that is difficult to quantify. There were also confounding variables that were impossible to control in the actual implementation of the study. It is important to note that the space used for the experiment included some unanticipated sound bleed issues. The physical space was located inside a self-contained room (without Wenger soundproofing) in a very chaotic and cacophonous children’s science museum with numerous noisy exhibits. Since this was a study about whether ambient sound could create engagement and deeper learning, sound was an important consideration in this experiment. It was hoped that the volume of the audio in the Towards Utopia learning system was sufficiently loud to create a degree of immersion and engagement with the tangible user interface, and that this would compensate for some sound bleed issues.

However, it is possible that the increased volume of the program material was not sufficient to overcome the effects of the noise bleed, and that the sound contamination from the science museum space contributed to the lack of measurable difference between the sound:on and the sound:off group. It is also important to consider that even if a similar experiment were conducted in a conventional classroom environment, there would still be a substantial level of
ambient noise. The only way to avoid potential confounding variables would have been to run the experiment inside a very large Wenger acoustically soundproof room.

It is also important to note that although there were some sound bleed issues, it was not a fatal flaw to the experiment. I was easily able to transcribe the audio tapes of the interviews with the children even though many of the children spoke quite softly. Had the sound bleed issues been severe, this would not have been possible.
## 1.4 COGNITIVE THEORIES & MEDIA THEORIES USED

<table>
<thead>
<tr>
<th>Theoretical Framework</th>
<th>Description</th>
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<tr>
<td>Depth of Processing Theory</td>
<td>The addition of ambient sound should improve the memory of the learning material. Information may be processed in a somewhat deeper and fuller way than it otherwise would have been, and thus be remembered better. (Craik &amp; Lockhardt, 1972)</td>
</tr>
<tr>
<td>Dual Coding Theory</td>
<td>Information channels are separate and distinct, and there is a greater potential for learning when both auditory and visual information are presented. (Paivio, 1986; Sweller, 1994)</td>
</tr>
<tr>
<td>Memory Traces</td>
<td>A memory trace consisting of verbal, visual and auditory information. The implication for multimedia and tangible user interfaces is that it is easier for the brain to retrieve multiple modes of information. Information stores are therefore richer than compared to information presented through only a single modality. (Kieras, 1978; Atwood, 1989)</td>
</tr>
<tr>
<td>Emotional Impact</td>
<td>It is the emotional response which implies that for tangible user interfaces adding ambient sound (auditory channels) to learning environments can potentially increase emotional impact which in turn will increase the memorability of the experience leading to deeper learning. (Lang, 1979; Shielk &amp; Jordan, 1983)</td>
</tr>
<tr>
<td>Suspension of Disbelief</td>
<td>The concept of suspension of disbelief serves to increase engagement and enjoyment with the educational content. The addition of ambient sound may increase suspension of disbelief. (Murray, 1997 &amp; Zimmerman, 2004)</td>
</tr>
<tr>
<td>Engagement</td>
<td>As contributes to cognitive engagement involving attention to the activity which promotes “useful” learning. (Murray, 1997 &amp; Zimmerman, 2004)</td>
</tr>
</tbody>
</table>
1.5 ORGANIZATION & OVERVIEW OF THESIS

This first chapter has provided a general overview of the research project. Chapter 2 provides an examination of the literature relevant to the subjects of suspension of belief, immersion, engagement and related concepts, a history of technological attempts to implement and enhance suspension of disbelief and similar experiences, theoretical issues relevant to the use of ambient sound, and issues related to the practical implement of ambient sound. Chapter 3 includes a discussion of the main theoretical and design considerations that were used to construct the Towards Utopia tangible system which formed the research instrument for the project. Chapter 4 describes the experimental methodology, including the experimental design, data collection and analysis methods. Chapter 5 presents the results of the study, and Chapter 6 discusses the implications of the findings.
CHAPTER 2: REVIEW OF THE LITERATURE

This chapter presents a review of literature relevant to the educational potential of ambient sound as a means of improving the effectiveness of use with tangible user interfaces.

As Cuban (1986) points out, in 1922, Thomas Edison claimed that within a few years, motion pictures would completely replace all text books in schools. Nearly a century later, while films and videos have proven valuable tools for education, they still show no signs of replacing text books. Similar prophecies have been made for television, video tapes, DVDs, computer games, the internet and virtual reality. We must greet grandiose claims for the roles of any technological innovation with a healthy scepticism. Even so, many authors have noted that computerized educational programs, virtual reality and similar methods are making great inroads into the education system, and are being implemented with considerable success not only in schools but also in businesses, hospitals and the military.

Since much of the interest in ambient sound centres upon the possibility it has the potential to enhance the sense of realism, and create an experience variously referred to with terms such as “suspension of disbelief,” “immersion,” or “engagement,” I will examine materials related to this cluster of concepts. This will be followed by a brief history of technological attempts to create or enhance
the experience of suspension of disbelief, immersion, engagement and related experiences. A third section will include a theoretical discussion of the reasons for suspecting the addition of ambient sound to educational program material might cause it to be more engaging. In the final section, material related to practical efforts to add ambient sound to educational material will be considered.

2.1 IMMERSION

When attempting to sort out the various terms employed to describe immersion and similar states and experiences, one is reminded of the famous proverb of the five blind men examining an elephant with their hands, then attempting to explain what an elephant is like. The blind man who touched only the elephant's leg declared an elephant to be a tree or a post, while the blind man who handled only the trunk declared an elephant to be a kind of snake. The descriptions from each investigator of what is essentially the same phenomenon can seem radically different, each based on differences in emphasis, priority or focus.

Immersion is generally defined as the state of being immersed and deeply involved in an activity. However, this term immersion is widely but inconsistently used by many in the fields of entertainment, computer game development and virtual reality, and does not always refer to exactly the same class of experiences. In computer terms, immersion is the state of being engrossed in the computer environment with intense focus. It involves the disappearance of critical distance and an increased emotional involvement with
the content (Grau, 2003). Salen and Zimmerman (2003) state that immersion comes not from the game but rather through play. These authors state:

"the idea that the pleasure of a media experience lies in its ability to sensually transport the participant into an illusory, simulated reality. According to the immersive fallacy, this reality is so complete that ideally the frame falls away so that the player truly believes that he or she is part of an imaginary world. (p. 450)

Andrew Glassner (2004) states there are various different levels of immersion. Stage one is a casual desire to learn. Stage two is sympathy of a sort in which the person is “transported” from being simply a viewer to sharing the viewpoint of the protagonist. Stage three is empathy and emotional bonding with the protagonist. Stage four involves an even higher level of such transportation, to the point the player loses the boundary between his own reality and that of the protagonist (p. 81-84).

Various authors who have considered the matter have concluded the important issue is not so much the levels of the experience as it is the fact that the phenomenon has multiple dimensions. For instance, Staffan Björk and Jussi Holopainen (2005), in *Patterns in Game Design*, divide immersion into several distinct categories: emotional immersion, spatial immersion, cognitive immersion, sensory-motoric immersion and psychological immersion. Emotional immersion is created by responding to the actions of the characters within the game, and is similar to the kind of immersion people frequently experience when reading fictional literature, watching theatre or movies. By spatial immersion, they refer to the results of extensive manoeuvring within the world of the game.
Video games, virtual reality and participatory theatre can have this quality, but the reading of fictional literature does not. Cognitive immersion refers to the intense focus on abstract reasoning and problem-solving activities that some kinds of games and virtual words require. Sensory-motoric immersion is the result of the feedback loops between movements made by players in interactive games. The general concept seems to be that if one continues to respond with physical movements to actions on the screen, at least to some extent, fairly soon this will lead to a “feeling” the on-screen images and events are real, even if one cognitively knows they are not.

Bjork and Holopainen (2005) also refer to what they call psychological immersion, which supposedly occurs when a player confuses the game with real life. Bjork and Holopainen seem to doubt the existence of this last category:

“Although claimed as one of the greatest dangers with playing [computer] games, psychological immersion, or the confusion of the Game World with the real world, has not been verifiable under rigorous examination.

Although highly immersive games have been widely available for more than 30 years, and many have suggested they may be dangerous, no one has yet documented a single plausible case of a suicide, homicide, act of violence or crime against property caused by the apparent confusing of game activity or their imaginary characters with the real world (Dear, 1991). Since a sizable portion of the millions of people playing these games have probably been mentally ill, disoriented or intoxicated at the time, it is significant that no such confusion seems to have
occurred yet. This is all the more remarkable since violent fights over “real life” sports like soccer matches are not uncommon.

There are other possible category systems for mapping out the phenomenon. For instance, Ermi and Måyrå (2005, p. 7) suggest there exists three dimensions to immersion. The first dimension is what they refer to as “sensory” immersion. In sensory immersion, the focus is upon the gameworld through overwhelming the senses, such as through the use of high volume audio and intense, large scale, vivid graphics presented on a large screen. The presumption here is that if the senses are totally occupied with the gameworld, they are cannot be simultaneously focused upon the real world. For Ermi and Måyrå, the second dimension is referred to as “challenge-based immersion.” In challenge-based immersion, the player is continually engaged with challenging activities which make heavy demands upon their skills and abilities. A continuous stream of such challenges tends to absorb virtually all of the player’s attention, and they therefore have little attention left over to focus upon external reality. The third dimension is imaginative immersion. In imaginative immersion, the player uses fantasy to create emotional bonds with the characters in the game world through imaginative play.

Although the number of dimensions and their descriptions are quite different in Bjork and Holopainen’s (2005) scheme than in Ermi and Måyrå’s (2005) system, upon reflection, it is possible to see a considerable degree of overlap. For instance, Bjork and Holopainen’s emotional immersion,
psychological immersion, and to some extent, even their description of cognitive immersion, could be viewed as being approximately equivalent to Ermi and Máyrá’s imaginative immersion. Likewise, Bjork and Holopainen’s sensory-motoric immersion could be viewed as being essentially equivalent to Ermi and Máyrá’s concept of challenged-based immersion. Bjork and Holopainen’s description of spatial immersion fits the description of challenged-based immersion nearly as well.

Ermi and Máyrá’s (2005) system is also remarkably useful for classifying some of the other diverse descriptions of immersion found in the literature. For instance, in their book entitled Rules of Play: Game Design Fundamentals, Salen and Zimmerman (2004) discuss the connection between immersion, suspension of disbelief, and the factors which facilitate the perception that a game is being played. In this work, they discuss the concept of the “magic circle.” According to this view, play takes place within a magic circle. The magic circle is defined as the mental/social space within which the game takes place - an artificial, consensually-created “alternate reality” perceived as being distinct from ordinary reality. Within this magic circle, a state of play is understood to be in operation, with its own highly contrived meanings, arbitrary rules, peculiar agreements, and unique assumptions about what is happening. In this magic circle, the ordinary rules and expectations of the “real” world are tacitly understood to not apply. It is a finite space with infinite possibility- a place where the learner is able to suspend all disbelief. Salen and Zimmerman, (p. 95),
cite Steve Sniderman’s essay (1999), “The Life of Games,” who says that during a game:

“a human being is constantly noticing if the conditions for playing the game are still being met, continuously monitoring the ‘frame,’ the circumstances surrounding play, to determine that the game is still in progress...the frame of a game is what communicates that those contained within are ‘playing’ and that the space of play is separated in some way from that of the real world.

Psychologist Michael Apter (1991) expresses a similar opinion about this magic circle:

“In the play-state, you experience a protective frame which stands between you and the “real world” and its problems, creating an enchanted zone in which, in the end, you are confident that no harm can come. Although this frame is psychological, interestingly it often has a perceptible physical representation: the proscenium arch of the theatre, the railings around the park, the boundary line of the cricket pitch, and so on.

Paras and Bizzocchi (2005), addressing the same concepts, say the spatial properties of digital environments are thought to entice the learner to enter game space, and this game space is created through the use of compelling graphics, sound, and physical interaction. This suggests that if the world created is rich enough, then and only then “the magic circle can be entered.”

In all of these descriptions of this alternate reality of the magic circle, there is a notion of a special, highly contrived psychological/social space or state which serves as frame within which a game is to be played. Although these descriptions all define this magic circle as being artificial and purely psychological/social in nature, they all emphasize the fact that subtle aspects and
cues from the external environment can greatly facilitate its generation and maintenance. Although different terminology is being used by Salen and Zimmerman (2003), Sniderman (1999), Apter (1991) and Paras and Bizzocchi (2005), and their descriptions cannot be said to match exactly on all points, all of their descriptions of this magic circle/play-space seem to correspond quite closely with Ermi and Måyrä’s (2005) definition of imaginative immersion. Paras and Bizzocchi (2005) particularly add the interesting claim that sensory immersion supports the creation of imaginative immersion.

Let us consider another example. According to Collins, in his book Game Sound (2008, p. 134), audio plays a very significant role in the immersive quality of a game. Any interruption in gameplay from any source - whether from drops in frame rate playback, sluggish interface reactions, or from something else - distracts the player and detracts from the immersion. Collins claims interruptions in music, such as hard cut transitions between cues, constitute an especially powerful disruption to the process of creating immersion.

As with the previous examples, Collins’ (2008) definition of immersion seems to fit easily into Ermi and Måyrä’s (2005) scheme as well, being a nearly perfect match with their description of sensory immersion. As we proceed, we discover that many other diverse terms and definitions map remarkably well on to one or more dimensions of Ermi and Måyrä’s three-fold classification scheme.
2.2 SUSPENSION OF DISBELIEF

The concept of “suspension of belief” emerged from nineteenth century discussions of what made good fictional literature, but the same concept applies to live theatre, cinema or more recent multimedia presentations. The willing suspension of disbelief is a phrase coined by the poet Samuel Taylor Coleridge (1817) to justify his use of surrealistic, fantastic or non-realistic elements in his poetry.

Poetry and fiction involving supernatural themes and elements had largely gone out of fashion in the late 1700s, in part due to the declining belief in witches, elves, ghosts, spirits, and other supernatural entities among the educated classes, who embraced a more “rational” worldview as a result of their exposure to science. Coleridge hoped to revive the use of fantastic elements in poetry. His concept of willing suspension of disbelief was intended to present such of stories and poetry to a modern, educated, and supposedly more “enlightened” audience in a way that would permit them to continue to appreciate and enjoy them.

Coleridge suggested if a writer can infuse a “human interest and a semblance of truth” into a fantastic tale, the reader would suspend judgment concerning the implausibility of the narratives. Coleridge hoped the use of such fantastic elements might increase the receptivity of the audience to the ideas conveyed in the fictional work.
Coleridge coined the phrase in reference to his collaboration with William Wordsworth for their *Lyrical Ballads* (1798). Coleridge (1817, ch 14) explained his concept this way:

"... it was agreed, that my endeavours should be directed to persons and characters supernatural, or at least romantic, yet so as to transfer from our inward nature a human interest and a semblance of truth sufficient to procure for these shadows of imagination that willing suspension of disbelief for the moment, which constitutes poetic faith. Mr. Wordsworth on the other hand was to propose to himself as his object, to give the charm of novelty to things of every day, and to excite a feeling analogous to the supernatural, by awakening the mind's attention from the lethargy of custom, and directing it to the loveliness and the wonders of the world before us; an inexhaustible treasure...."

By introducing this notion of suspension of disbelief, Coleridge started a controversy that remains unresolved. Artists, philosophers, psychologists, educators, film makers, dramatists, educators, writers and literary critics still argue about what Coleridge actually meant, whether his claims had any validity, and to what degree they still might be relevant to contemporary media.

Although this concept has been widely used by artists since Coleridge invented it, and although there is something intuitively very appealing about it, various aesthetic philosophers and others have criticized the phrase "suspension of disbelief," arguing it does not accurately characterize the relationship between reader/audiences and fictional material. Kendall Walton (1978) notes that, if viewers were to literally suspend disbelief while watching a horror movie and accept images on the screen as if they were real, they would respond with a genuine set of emotional and behavioural reactions. For instance, audience members would cry out, "Look
behind you!" to an endangered on-screen actor or summon the police after they witnessed an on-screen murder. Clearly this is not how even the most enthusiastic audiences normally react to films.

Similarly, as Lazarowicz (1997, p. 97), in his introduction to theatre studies points out, members of the audience do not normally jump up and run out of the theatre when one of the onstage actors yells “fire!” And more importantly, Lazarowics notes, if they did, this would not be evidence the theatre was creating the intended effect on the audience, but rather evidence the intended form of communication had failed.

In reference to fictional writings, Pavel (1975, p. 169) points out, even the most avid fan of Sherlock Holmes novels, when confronted with a real life need for the services of a private detective, does not begin searching for Sherlock Holmes in the Yellow Pages. If they did, this would not be because the normal and intended effects of the fictional story had been successful, but would instead serve as evidence the reader had responded in a most unusual, unexpected way - completely opposite of the effect intended by the author of the fictional stories. Once more, Pavel’s example seems to show that what is intended when creating fictional stories is not actually a suspension of disbelief, or creation of belief, but rather some experience of a different order.

In the early 1800s, the poet John Keats made a somewhat similar argument about the vividness of the mental imagery (Rossetti, 1887). According to Keats, extreme vividness of imagery evoked by poetry, even when highly surreal and
fantastic, was capable of eliciting emotions, particularly compassion and sympathy. Through this method, fantastic imagery allowed readers to experience empathy for and appreciate the suffering of classes of people they would never be able to meet in the real world. For Keats, internal mental imagery for all five senses had this capability. The empathy generated in this way would be much superior to that generated by ordinary verbal discourse, presentation of factual information or logical arguments. For Keats, the issue was never a matter of creating belief or suspending disbelief, to him, imagination was a distinct organ of intelligence apart from reasoning, logic and belief. Imagination was a means for eliciting emotions that transcended any notions of persuasion, facts, belief or disbelief. Though Keats worked solely within the domain of poetry, his claims were seen as being equally valid for artists working in other media including prose fiction, painting, theatre and music as well as cinema and other information technologies which would not appear until long after Keats’ lifetime.

Despite the fact that Walton, Lazarowics, Pavel and Keats all take exception to some extent with the formulation of Coleridge, as well as with each other on various points, their basic descriptions of the phenomenon under discussion still displays considerable underlying unity. All of these descriptions, most especially Coleridge’s notion of suspension of disbelief, can easily be subsumed under the rubric of Ermi and Måyrä’s (2005) description of imaginative immersion. As Gregory Bateson (1972) points out, part of what must be happening with such fictional communications is that on at least some level,
the audience member knows the communication has the nature of play, and that they are at least tacitly agreeing to be a participant in this play. If for some reason this awareness breaks down, the effect is destroyed. This is what authors as Lazarowisc (1997) and Knoop (2007) refer to as a “metacommunicative contract.”

Christine Knoop (2007) points out that when this effect is achieved, despite of, or arguably because of it, intense and sometimes enjoyable emotional responses can often be generated as a result. However, like Bateson, Knoop acknowledges part of what makes this possible is retention of awareness the events of the fictional story are not real:

“We can read about Tolstoy’s Anna Karenina throwing herself under an incoming train and get emotionally shattered by that without having to deal with real suicide; thus the knowledge that what is happening is fictitious makes it possible to handle it and maybe even enjoy the emotionally painful experience.”

J.R.R. Tolkien, the author of the famous *Lord of the Rings* trilogy of fantasy books, extends this thinking even further. For Tolkien, (Reilly, in Zimbardo & Neill, 2005) what makes such fantasy worlds interesting is not their similarity to the “real world,” but rather their complete or near-complete disconnection and independence from the real world. Such worlds are for Tolkien, not virtual realities, but “secondary realities.” They appeal to people, not because of their fidelity to the real world or their ability to be mistaken for the real world, but because they are internally self-consistent realities in their own right, with their own rules, operating principles and “facts” that may have little or no correspondence to the so-called “real” world.
For Tolkien, somewhat reminiscent of Keats, the suspension of disbelief does not describe what is going on when one engages with such a fantasy world. Instead, what occurs is the active, consensual use of one’s mental faculties of imagination and fantasy to create realities the reader knows are contrary to ordinary reality. For Tolkien, as delightful, enjoyable and fun as this process of “making beliefs” may be, it is a very serious matter. This is because it is very close (if not identical to) what highly religious people call “faith.” This same kind of deliberate, consensual agreement to create mental images and beliefs about reality that are contrary to factual reality, as Knoop and others point out, can frequently lead to the generation of intense and very satisfying emotional states. Although Tolkien’s interpretation of all this is sometimes considered greatly at odds with Coleridge’s original description of what “willing suspension of disbelief” is about, we can note that in Coleridge’s original explanation of the concept, he did seem to be equating willing suspension of disbelief with “poetic faith.”

Though his critics often speak of Coleridge’s concept of suspension of disbelief as if it were a totally passive state, it is worth noting that Coleridge did not simply call it “suspension of disbelief,” but explicitly referred to it as the “willing suspension of disbelief.” This could be taken to mean he wished to emphasize the deliberate, intentional and voluntary aspects of the phenomenon, and was not thinking in terms of it being something passive or mechanical.
Despite their greater emphasis on the voluntariness and consensuality of the process, Bateson’s, Knoop’s and Tolkien’s thoughts on the matter all still seem to fit quite well within Ermi and Máyrá’s (2005) concept of imaginative immersion.

Discussing the matter of cinema, theatre, computer games and virtual reality projects, Pimentel and Teixeira (1993, p. 154), take a similar position to that of Bateson, Knoop and Tolkien:

"There’s a subtle agreement, a kind of social contract, between the audience and the experience designer. For a simulation to be believable and engaging, there needs to be roles and boundaries assigned to both sides of the curtain. Neither the designer nor the user actually believe the actions on the stage or in the computer are real, but they agree to pretend as if they are real. There’s safety in the knowledge that they can escape at any time by leaving the theatre or turning off the computer."

Pimentel and Teixeira (1993) also say this about immersion:

"The creation of an environment requires the immersion of your senses in a computer-generated world to create the experience of “being there.” The question isn’t whether the created virtual world is as real as the physical world, but whether the created world is real enough for you to suspend your disbelief for a period of time. This is the same mental shift that happens when you get wrapped up in a good novel... You stop considering the quality of the interface media and accept the computer-generated world as a viable one. (p. 15)"

Although what Pimentel and Teixeira (1993) say about the importance of what sounds like sensory immersion being a key factor in the creation of suspension of disbelief, in essential agreement with what Paras and Bizzocchi (2005) say on the matter, their concept of immersion still corresponds quite closely with Ermi and Máyrá’s (2005) concept of imaginative immersion.
Other recent authors, such as Janet Murray (1997), have also taken positions which are quite similar to that of Tolkien:

"The pleasurable surrender of the mind to an imaginative world is often described, in Coleridge's phrase, as "the willing suspension of disbelief." But this is too passive a formulation even for traditional media. When we enter a fictional world, we do not merely "suspend" a critical faculty; we also exercise a creative faculty. We do not suspend disbelief so much as we actively create belief. Because of our desire to experience immersion, we focus our attention on the enveloping world and we use our intelligence to reinforce rather than to question the reality of the experience. (p. 110)"

Specifically in reference to virtual environments and other computer-generated games, imagery and media, Murray says:

"The great advantage of participatory environments in creating immersion is their capacity to elicit behavior that endows the imaginary object with life. The same phenomenon occurs when a child rocks a teddy bear or says "bang!" when pointing a toy gun. Our successful engagement with these enticing objects makes for a little feedback loop that urges us on to more engagement which leads to more belief. As the digital art medium matures, writers will become more and more adept at inventing such belief-creating virtual objects and at situating them within dramatic moments that heighten our sense of immersed participation by giving us something very satisfying to do. (p. 112)"

For Murray, the central issue still seems to be about belief. However, for her, rather than the mere suspension of disbelief, Murray goes further and emphasizes the active creation of belief. Although Murray’s concepts are more or less consistent with those of Bateson, Knoop and Tolkien, by stressing the issue of active creation of belief as she does, she could be seen as going even further down the same road as these other authors, and taking a even stronger stance on the matter than even Coleridge himself may have taken. She also emphasize the importance of the participants being
able to interact with “virtual objects” as means for enhancing the creation of belief.

Even so, Murray’s understanding of active creation of belief nevertheless seems to still be clearly within the general scheme of Ermi and Máyrá’s (2005) three-fold framework, being essentially equivalent to their description of imaginative immersion.

2.3 FLOW

Murray’s discussion of the importance of interactivity brings us to an additional term frequently encountered in the discussion of these matters. Csikszentmihályi (1990) introduced another concept he referred to as “flow,” which many have associated and sometimes at least partially equated with immersion, suspension of disbelief and similar or related experiences. Csikszentmihályi identifies flow as a state of total mental absorption in an activity:

“...being completely involved in an activity for its own sake. The ego falls away. Time flies. Every action, movement, and thought follows inevitably from the previous one, like playing jazz. Your whole being is involved, and you’re using your skills to the utmost. (Csikszentmihályi, 1996)

One of the key factors necessary to induce this state of flow is that the task must be somewhat challenging. There must be at least some uncertainty, some possibility of failure or at least some risk of an unpleasant outcome. If the task is too easy and undemanding, it is boring, and attention wanders away from it. However, if the task is too difficult, it creates anxiety and frustration, which also
disrupt the induction and maintenance of the experience of flow. When in a state of flow, attention is completely absorbed and focused on the tasks and challenges at hand, and it may be very difficult for other stimuli to pull the person’s attention away. In flow, there is a tendency to lose track of time, but in Csikszentmihályi’s descriptions of the state, there is no claim that suspension of belief, active creation of belief for anything resembling such processes is a necessary component or correlate of flow.

Ernest Adams (Rollings & Adams, 2003), co-founder of the International Game Developers Association, uses the term “tactical immersion” in a way that is essentially synonymous with Csikszentmihályi’s definition of flow. According Adams, tactical immersion is experienced when performing tactile operations that involve skill. Players feel “in the zone” while perfecting actions that result in success.

The typical descriptions of flow seem to make it quite a distinct phenomenon from that of either sensory immersion or imaginative immersion. Such descriptions of flow always emphasize the central importance of a stream of actions which requires the participant to behave in a manner that challenges their skills and abilities, but the descriptions of sensory immersion and imaginative immersion do not include such a requirement. However, as noted by authors such as Bizzocchi (2007), and Ermi and Máyrá themselves (2005), flow is actually the prime example of what Ermi and Máyrá refer to as challenge-based immersion.
2.4 APODICTICITY

There is yet another relevant term that must be taken into account: apodicticity. This concept of apodicticity apparently originated among the ancient Greek philosophers, and refers to the feeling that something is real. It refers not to anything as abstract as belief or conscious decisions to pretend something is real, but rather to a very visceral, kinesthetic experience of something being real, apart from any objective facts or reality. When we say that pre-modern cultures believed the world was flat or that the sun revolved around the earth, strictly speaking, this is an erroneous and misleading statement. Such people did not simply believe the world was flat or the sun moved around the earth. It would be more accurate to say that for them such claims felt like a self-evidently obvious description of reality - such claims possessed apodicticity, and any contrary claims lacked apodicticity for them. In a nightmare, the monster chasing you evokes terror, yet a similar monster on a movie screen does not. This is because the monster in the nightmare has apodicticity. The monster on the movie screen does not.

As Kevin Hemberg (2007, p.25), describes it, “one may be mistaken about the tree one sees, but one cannot be mistaken about the experience of seeming to see a tree – the experience, the consciousness of the tree.”

Apodicticity, then, is not the cognitive belief that something is real, but rather the visceral, kinesthetic sense of something *seeming* to be real. This feeling
may lead to or contribute to the belief that something is real, but the feeling and the belief are separate experiential components.

This notion of apodicticity is very close to Bjork and Holopainen's (2005) notion of psychological immersion in which an individual begins to confuse the artificially created game world with the real world. This again reminds us of Tolkien's concept of suspension of disbelief/make-believe being similar to religious faith, with apodicticity being the point where a person loses sight of the distinction between invented beliefs and mistakes them for actual reality. There have not been suicides, homicides and major felonies committed as a result of immersive computer games, whereas such acts are commonly committed by devoutly religious people, fanatics and political extremists. Whatever absorption and excitement computer games can arouse, these artificial realities seem to be lacking the element of "high seriousness" that the "artificial realities" of religion and political ideology seem to possess. Perhaps this fact demonstrates the error in equating the "faith" created by people playing video games and the faith/make-believe created within the minds of religious people or other true believers. This suggests even the most successful computerized efforts to create psychological immersion, apodicticity or suspension of disbelief are still different in some significant way from genuine belief or faith, at least in degree if not in kind.

Ever since Coleridge, the debate has continued regarding what factors promote and which discourage this experience of suspension of disbelief/
immersion/engagement/apodicticity. It has been noted that when the toga sleeve of the actor playing a Roman centurion slides down and reveals him to be wearing a watch, this disrupts the effect. Likewise when an actor in a western film slips and refers to his partner, (John Wayne), as “Mr. Wayne,” instead of “Mister Cogburn,” the successful suspension of disbelief built up to this point is temporarily dispelled. In the play, The Trial of A. Lincoln, (Damico, 1969), at a moment of high dramatic tension, when following the script, the actor playing Abraham Lincoln pulls off his beard, revealing he is not Abraham Lincoln but merely an actor. For many of the audience, this sudden disorientation dispels the suspension of disbelief, and many of them leave without watching the remainder of the production.

Following Tolkien, the important factor may not necessarily be the fidelity to “known facts” about “the real world,” but rather the internal consistency of the imaginary world. The effect may be enhanced when the Queen of the elves looks, sounds, and behaves as the queens of elves should look, sound and behave according to the rules of the imaginary world, and destroyed if she acts contrary to these expectations (Zimbardo & Neil, 2004). This is nonetheless true despite the fact the audience knows that in the real world elf queens do not exist at all.

Failure to achieve the desired goal of suspension of disbelief may be due to any number of deficiencies with the presentation that causes it to less than fully capture attention or sustain attention. Whatever term they may have used for this experience, the creators of literature and other works of art have been
acutely aware of this problem. Show business, entertainment and educational programming are very important parts of the modern world, and a great deal of effort and thought continues to be expended on how to improve this effect.

Apodicticity is more difficult of neatly fit into Ermi and Måyrä’s (2005) three-fold description of immersion. It does not seem to involve the kind of performance challenges required to fit the definition of flow or challenge-based immersion. Although it involves perceptions that “feel” real, it does not fully fit the description of either sensory immersion or imaginative immersion, but rather seem to hover somewhere on the boundary between sensory and imaginative immersion.

2.5 ENGAGEMENT

Murray, with her discussion of interacting with belief-creating virtual objects, leads us to yet another term used in such literature: engagement. Murray seems to say it is this engagement which leads to immersion, and immersion that leads to make-believe or active creation of belief. Other authors seems to use immersion and engagement more or less interchangeably. Whatever the case may be with this, the term engagement is frequently encountered in discussion of this matters.

What then, does the term engagement refer to? Partially because terms are often used very loosely and interchangeably, immersion and engagement can be difficult to tease apart, but they do seem to refer to at least some what distinct concepts. Pimentel and Teixeira (1993, p. 69) describe engagement like this:
How interesting is the application? Does it capture your interest? This is one of the most difficult factors to judge, but it can have a tremendous effect on the sense of presence in the virtual world.

This raises an important distinction, and illustrates the level of absorption and the degree of interest and potential learning may well be completely separate from suspension of disbelief or even active creation of disbelief. A program might at least theoretically prove to be extremely engaging despite the fact it has little sense of “reality” to it. It is important to note that suspension of disbelief/active creation of belief does not necessarily equate with a close semblance of reality, as demonstrated by the example of cartoons. Indeed, one is again reminded of Tolkien, who pointed out the fantasy worlds like that of the Middle Earth in the Lord of the Rings are attractive, inspiring and engaging not because they have close correspondence to the known and familiar “real” world, but specifically because they are very different from the familiar real world. This has practical considerations for program design because it implies that making programs that are highly realistic does not necessarily make them engaging and immersive, and that there may be ways of designing content and programs which lack all pretence of realism but are nevertheless extremely engaging.

It will be valuable to examine how Xie, Antle and Motamedi, (2008) describe engagement:

“Engagement has been commonly conceptualized as a kind of mindfulness requiring cognitive effort and deep processing of new information... This conceptualization is relevant for children’s play since a dominant function of play is learning. Learning requires engaged attention.”
Xie, Antle and Motamedi (2008) define engagement more or less as Pimentel and Teixeira (1993) had done, as a high level of absorption in an activity, with engagement being characterized by intense focus of attention, and mobilization of cognitive, affective and motivational strategies for a specific task, with a strong correlation with activities that are experienced as interesting and enjoyable.

The key element of engagement seems to be the capturing and sustaining of attention. This distinction becomes more important when we understand that even in a presentation that does not create a convincing alternative world, the characteristics of the presentation might nevertheless be extremely engaging, and therefore be high memorable. Perhaps the vividness of the images, intensity of the sounds, novelty and attractiveness of the ideas presented could capture the attentive processes of the mind, even in the absence of lifelike props or realistic special effects.

Although the kinds of experiences various authors have use to define engagement clearly are related to the various forms of immersion we have been discussing, attempting to classify engagement in terms of Ermi and Máyrá’s (2005) three-fold description of immersion of turns out to be difficult to accomplish. Although many of the electronic games and much fictional literature which could be characterized as inspiring imaginative immersion seem to be highly engaging, many other activities that would fit Pimentel and Teixeira
(1993) or Xie, Antle and Motamedi’s (2008) description of engagement do not evoke a high degree of imaginative immersion. Therefore, it does not seem we are justified in thinking of engagement as yet another synonym for imaginative immersion. Similarly, there is nothing in any of the descriptions of engagement that presuppose the necessity of the kind challenging activities that are the essence of flow, so it does not seem possible to equate engagement with flow or challenge-based immersion, even flow-inducing activities would seem, by definition, to be quite engaging. Likewise, it does not seem to be the case that engagement is a synonym for sensory immersion either, for many games, such as Tetris, seem to be extremely engaging despite their lack of vivid graphics or overpowering audio (Ermi & Mäyrä, 2005). Although engagement seems to be involved in all three of different types of immersion described by Ermi and Mäyrä’s (2005) three-fold classification scheme, it seems that engagement does not really fit inside this classification scheme. Engagement seems to be a somewhat more inclusive term that can encompass all three of the different kinds of immersion, but seems to be even more generic than any of these three specific kinds of immersion.

To summarize this section, it seems that, although not perfect, Ermi and Mäyrä’s (2005) three-fold description of immersion is the most clear and useful available system for making sense of the numerous, often confusing, overlapping, contradictory and sometimes vaguely-defined terms for referring to
concepts related to immersion. Therefore, this system of terminology will be used throughout the remainder of this thesis.

In this way of thinking, the generic term immersion includes the group of three distinct but related kinds of immersion: (a) imaginative immersion; (b) challenge-based immersion; and (c) sensory immersion. From this perspective, both the terms suspension of disbelief (Coleridge, 1817) and active creation of belief (Murray, 1997) can be considered special cases or subtypes of the more generic term imaginative immersion. Similarly, the term challenge-based immersion refers to Csikszentmihalyi’s (1990) concept of flow, and all similar or related terms which refer to a kind of immersion elicited by engaging in activities which challenge the person’s skills and abilities. Likewise, the term sensory immersion is the appropriate label for types of immersion in which the vividness, intensity, salience and/or apparent realism of the presentation commands the attentive processes to the extent that external stimuli are largely ignored, and the presentation “feels” real.

The term engagement, as discussed by Xie, Antle and Motamedi (2008), seems to represent an even more generic class of experiences related to intense interest, attention and mobilization of mental and motivational resources, which correlate reasonably well with enjoyment, even though engagement is as very a distinct class of experience from enjoyment. Engagement seems to be the appropriate label for a more global and generic category that can refer collectively to the entire class of experiences characterized by the intense and
sustained focus of attention, including but not limited to all three of the types of immersion discussed by Ermi and Måyrä (2005).

Generally speaking, for this project, most of the effort was expended towards attempting to create a tangible interface that would generate imaginative immersion, with some attempt to accomplish this by creating sensory immersion. Minimal effort was dedicated to creating challenge-based immersion.

Therefore, in this document, when the intent is to be general and generic, the term engagement will be used. When not wishing to make a distinction between imaginative, challenge-based or sensory immersion, the more generic term immersion will be used. When attempting to refer generally to phenomenon of a sort similar to suspension of disbelief (Coleridge, 1817), active creation of belief (Murray, 1997), emotional immersion (Björk & Holopainen, 2005), psychological immersion (Björk & Holopainen, 2005), or similar types of experience, the generic term imaginative immersion will be used. When referring to experiences that are more similar to flow (Csikszentmihalyi, 1990), tactile immersion (Rollings & Adams, 2003), sensory-motoric immersion and related phenomena (Björk & Holopainen, 2005), Ermi and Måyrä’s more generic term challenge-based immersion will be used. More specific or narrow terms such as suspension of disbelief, active creation of disbelief, flow, etc. will be used when the intent is to be more precise or make reference to the concepts associated with a specific author.
2.6 HISTORY OF THE TECHNOLOGICAL IMPLEMENTATION OF SUSPENSION OF DISBELIEF

It will be useful now to offer a brief review of audio visual technologies, specifically with a focus on attempts to implement efforts to create this experience of immersion, suspension of disbelief, and engagement.

The earliest use of visual and auditory special effects is lost in antiquity. We know that many existing "primitive" cultures use masks, costumes, face paint, drums, music, bull-roarers and other props to produce special effects, including psychoactive substances to induce trances and altered states (Campbell, 1959). Shaman and "medicine men" use such techniques to communicate esoteric knowledge, important teachings, moral lessons and "revelations from the spirit world" to other members of the tribe. The existence of cave paintings in Europe implies such props were used even 20,000 years ago.

In later more urbanized settings of Europe and the Middle East, there existed what were referred to as "Mystery cults" (Burkert, 1987). In these cults, probably descendents and elaborations of old shamanic societies, the initiate worked through several layers of more superficial secret rituals towards the most profound ceremony, which supposedly imparted special secrets, divine revelations and even promised a direct experience of encountering the presence of supernatural beings in some convincing way.

We have a report claiming that a central experience of at least one of these ancient mystery cults involved the initiate experiencing the sight of some kind of artificially created, awe-inspiring glowing, moving image upon a wall inside a
darkened chamber that left them convinced they had experienced the literal presence of the Mystery cult god (Diodorus, 1989; Photius, 1994, 242). The mystical experience, whatever it was, evidently left the initiates convinced they had witnessed an epiphany of the god, and therefore convinced the truth and authenticity of the spiritual lessons taught by the cult were both genuine and authoritative (Hislop, 1845, p. 68).

Whether this image was the likeness of a face and body, was accompanied by voice or was merely an amorphous glowing dot, the impact was evidently great. We have no data about how the image was created, but do know the Greeks, Romans and Egyptians possessed lens, mirrors, relatively sophisticated knowledge of basic optics and reflective surfaces, and had engineers who possessed the cleverness to build simple projection devices should the need to do so arisen (Euclid 300 B.C; Heron, 70 A.D.). At least one “control room” has been found in the remains of such an ancient initiation centre, which included a clever system of pipes by which a hidden operator could speak verbal messages into one end of the pipe in the control room, have the sound be conducted many yards away into another room and be heard as coming out of the mouth of a stone statue of the cult’s god. This enabled the initiate to experience the teachings and message as if coming directly from the mouth of the god themselves, and respond accordingly (Burkert, 1987, p. 27).

The concept of using artificial visual special effects to help impress social, intellectual and ethical lessons upon an audience is a very old tradition. The use
of such technology to deceive parishioners for purely crass motives has often been suggested, but those more charitable towards older religious traditions might think in terms of using such technology to promote higher ethical teachings and moral lessons.

We know from records of Greco-Roman theatre that they often used technological means to achieve what we would call special effects. It was very easy for them to depict the presence of an ordinary man, woman, child, horse or chariot with great realism, since all they had to do was put the real thing on stage. The challenge they faced was how to create the presence of things like thunder and lightning, or more importantly, entities like gods, ghosts, demons, monsters or miraculous events that were so much a part of the mythical narratives their theatre was derived from. How were they to depict Romulus ascending from the earth into the heavens and transforming into a god? Or Euphemus running over the surface of the ocean without sinking or Dionysus magically transforming water into wine? How could they depict such events in a meaningful and artistically interesting fashion using 1st century B.C. technology? We know the Greeks and Romans had cleverly designed masks used in dramatic productions, including brilliantly engineered mouthpieces that served as primitive megaphones. Such mouthpieces altered the actor’s voice in dramatic ways appropriate to the character, and allowed them to be heard for greater distances. Most of these devices had little concern for reproduction life-life
quality of the sound, for they were more interested in how to create supernatural-seeming effects, not faithful reproductions of reality.

We know the ancient Greeks and Romans used clever lighting techniques and elaborate costumes and masks, trap doors to make characters appear and disappear, and hidden wenches to lift actors up off the staff so they could be seen descending from and ascending into heaven (Martin, 2000, p.131). We know they used elaborate types of brass noisemakers, had sophisticated apparatus for simulating thunder and lightning, and used some kind of three-sided prisms called periaktos to create interesting on-stage visual effects (Snodgrass, Carey & Roberts, 1988, p. 86), but we don’t have many details about the technology they may have used for more elaborate effects.

Many of these techniques survived and continued to be used in theatre throughout the middle ages. Elaborate arrangements of prisms, coloured glass and mirrors were used in clever ways to reflect light from the sun, lamps and candles to create visual effects (Beadle, 1994, p. 53).

An intriguing device referred to as a “camera obscura” used a mirror and a lens to project both stationary and moving images on a wall of inside of dark room. With a camera obscura, light from a bright area is transmitted through a pin hole or lens, reflected by a mirror, and projected onto a surface within a darker chamber, thus creating a moving image of whatever objects are in the brighter area. When focused properly, the image seen on the wall inside the darker room is a perfect reproduction of the actions occurring in the bright area.
from which the light had originated. Camera obscuras are believed to be the forerunners and inspiration for not only still photography, but eventually also motion pictures, television screens and more advanced imaging technologies.

The first unambiguous description of a camera obscura comes from the Persian scientist Abu Ali Al-Hasan Ibn al-Haitham, believed to have lived in Cairo, Egypt (965-1039 A.D.), known in the West as Alhacen or Alhazen. This description and his other experiments with light, images and reflective surfaces are included in his Book of Optics (Alhazen, 1021). Al-Haitham used the term “Al-Bayt al-Muthlim,” which translates into Latin as camera obscura, and into English as “dark chamber.” An improved version was recorded as having been built in the late 1500s in Naples, Italy, by Giambattista della Porta (1589), the Italian occultist/scientist. We don’t know where della Porta first encountered the camera obscura or what use it was being put to, but he was involved in various occult practices, and one cannot help but notice that such a device could easily be used to create the effect of seeing a ghost, god or spirit inside an otherwise empty dark room, as apparently had been experienced by initiates in various ancient mystery cults.

A camera obscura will eventually create a permanent picture if a fairly stabilized image projected by it is allowed to remain for very long period, with the “bleaching” effect of sun light “burning” in the image on an ordinary painted wall or dyed cloth. Documentation is sketchy, but observations of this effect probably led to the search for more photosensitive substances which would
display such images in a matter of hours or minutes instead weeks or months, and this process is apparently what led to the earliest photographs. The photosensitive properties of silver nitrate were known and described by Albertus Magnus at least as early as 1280 A.D. (Szabadvary & Svehle, 1992, p. 17). Silver nitrate was the active ingredient in early photographic plates and films.

There were experimental forms of photography performed with varying degrees of success at least as early as the 1820s, but the first practical photographs ("daguerreotypes") appeared in 1839-1840. Early photographs were often used as a tool for painters and sketch artists to work from while creating paintings or drawings, but even very early on it was noted even a mediocre photograph contained more detail and much greater realism than even the finest drawing or painting. Soon, photographs, especially of people, became popular in their own right (Hirsch, 2000).

The invention of the stereogram for adding depth to photographs seems to have occurred surprisingly soon after the invention of photography, with the first known stereoscopes appearing in the early 1830s (Pimentel & Teixeira, 1993, p. 22) and rapidly gaining in popularity soon thereafter. Stereography involved taking two separate photographs of a person or object from cameras placed about two inches apart to replicate the relative displacement of the two eyes within the human head. When viewed in a manner that lets each eye of the observer see the photographed object from the angle it would have naturally seen the real object, the processes of the brain combine the two images into one.
When this occurs, a strong sensation of realism and depth is added to the experience. What the viewer reports seeing is not two different pictures of the same object from two different angles, but rather one object with a sense of full three-dimensionality. This added illusion of depth and realism seems to have proven very attractive and appealing, and stereography quickly became extremely popular.

It apparently was taken for granted that increased realism was synonymous with increased attractiveness, and the concept of increasing the sense of realism in photography seems to have inspired many artists and inventors of the era.

The first known example of colour photography is attributed to James Maxwell in 1861 (Hirsch, 2000). The enhancement of realism was instantly appreciated, but it would be several more decades before colour photography became cost-effective enough for widespread use.

The idea of making motion pictures seems to have arisen remarkable soon after usable cameras and still photography came into being. By 1860s, various mechanisms for producing two-dimensional drawings in a manner that conveyed a sense of motion had come into being, including the zoetrope, the mutoscope and praxinoscope (Bardeche & Brasillach, 1938). These machines were outgrowths of simple optical devices (such as magic lanterns) and would display sequences of still pictures at sufficient speed, (approximately 10-12 per second) for the images to appear to be in motion, a phenomenon called
persistence of vision. If the presentation rate was less than 10 per second, the images were experienced as a sequence of still pictures, not a continuous stream in which the objects appeared to actually be moving. The images had to be carefully designed to achieve the effect, and the comprehension of this underlying principle became the basis for film animation and motion pictures. Even though none of these early technologies were ultimately successful commercially or aesthetically satisfying, their existence and continuing development reveals a remarkably sustained and committed effort to add the level of realism to photography that only motion could produce.

With the development of celluloid film for still photography, it eventually became possible to directly capture objects in motion in real time. An 1878 experiment by Muybridge in the United States using 24 cameras produced a series of stereoscopic images of a galloping horse resulted in what is generally considered to have been the first motion picture (Bardeche & Brasillach, 1938). Notice Muybridge’s technology had already incorporated not only motion but also stereoscopy and three-dimensionality. This attractive aspect of three-dimensionality was later abandoned as the film industry advanced because it was not deemed to be cost-effective. However, the attractiveness and realism of three-dimensional imagery had been noted even in the 1870s. Muybridge’s technology required a person to look into a viewing machine to watch the stream of images, which were a sequence of prints attached to a drum turned by a
handcrank. Coin-operated commercial versions of such machines appeared soon after.

By the late 1880s, the development of the motion picture camera allowed a sequence of images to be recorded on a single continuous reel. This led quickly to the development of a motion picture projector which could shine light through the film and, using the same basic concept and technology of the camera obscura, could magnify this series of images and display them on a screen for an audience. Such exhibitions came to be known as “motion pictures.”

During this same era, methods for electronically transmitting sound over a distance and recording sound for later playback were under research and development. Various devices now recognizable as microphones and earphones were experimented with by various individuals as early as the 1840s, but the first truly practical versions which connected a microphone to a headphone located some distance away via wires are generally attributed to Alexander Graham Bell (1876) and Thomas Edison (1879). Such devices allowed sound to be picked up at one location and heard at another, even when the two locations were many yards, or miles apart. The quality of the sound reproduction was not very great, but it was impressive to those experiencing it for the first time.

It was not long before successful attempts to increase the quality and realism of the electronic audio were made. Clément Ader demonstrated the first two-channel audio system in Paris in 1881, with a set of telephone transmitters (microphones) connected from the stage of the Paris Opera to a suite of rooms at
the Paris Electrical Exhibition. In these rooms, listeners could hear a live transmission of performances through receivers for each ear. It was not well understood why the use of a two-channel telephones was so dramatically superior in terms of sound quality and realism to a one channelled system, but it was understood it was due to more than a simple increase in the volume of the sound. A two-channel system was able to pick up and transmit important kinds of cues that a one channel system simply did not, and there was something about listening to this artificial sound with both ears that made such electronic audio seem far more real to the listener. An article in Scientific American (Dec 31, 1881, p. 422-423) reported:

“Everyone who has been fortunate enough to hear the telephones at the Palais de l'Industrie has remarked that, in listening with both ears at the two telephones, the sound takes a special character of relief and localization which a single receiver cannot produce. . . . This phenomenon is very curious, it approximates to the theory of binauricular audition, and has never been applied, we believe, before to produce this remarkable illusion to which may almost be given the name of auditive perspective.

Although there remained some mystery about why a two-channel electronic audio systems was so much more realistic and directional than a single-channel system, it was generally believed the entire effect was due to differences in amplitude between the two ears, or differences in the time it took sounds to reach each of the two ears (differential delay) from a given direction. Continued research related to the enhanced sense of spatiality, realism and depth in two-channelled sound eventually gave rise to what became stereophonic sound, or stereo.
The first known attempts to record sound were made by the Frenchman Martinville in 1857, with a device he called the phonautograph (Cowen, 2009). This would record sounds as a stream of squiggly lines etched on a smoked glass plate. The phonautograph offered no means of recovering and playing back the sounds it had recorded. However, the observation that sound could thus be captured and recorded inspired subsequent efforts to develop technology that could play such recordings back, the first successful devices of this type being the phonographs of Thomas Edison in 1877. Edison’s device, similar to that of Martinville, recorded sound as squiggly lines on a rotating cylinder. However, it also had the added feature of running a stylist through these groves to recreate the sound. The recordings of the voice made in this fashion were very low amplitude, and barely recognizable as human. However, the public was very impressed by the technology, and Edison believed it had great practical and economic potential.

Building upon his earlier successes, Edison invented the Kinetoscope in 1889, and made the first public demonstration of it in 1894 (Pimentel & Teixeira, 1993). This hand-cranked device allowed a viewer to watch a sequence of photographic images stored on a roll of film in a manner that conveyed a sense of motion. Although mostly remembered as the original form of motion pictures, Edison viewed them differently:

“"He was primarily interested in developing a visual accompaniment for his very successful phonograph. Edison intended the Kinetoscope to become a home entertainment machine capable of illustrating the sound from the phonograph. (p. 23)""
This is noteworthy because it is the opposite of the way we usually think about the subject, and the opposite of the way the film industry developed. To this day the prominence of visual information over audio information is marked, with audio often added (especially in multimedia) as an after thought.

For Edison, it was the audio that was the prime channel for conveying educational and entertainment information, and the visual was thought as an augmentation and enhancement of the audio information. The technology to synchronize the recorded audio with the movie pictures, either using an electric motor or a spring-driven device, already existed in the 1880s. If Edison had had his way, all movies would have contained both sound and imagery from that point forward. Except for a few experimental efforts, serious “talkies” would not be a part of the film industry until after 1927.

Even then, for years, many filmmakers continued to treat the concept of combining and enhancing cinema with synchronized sound tracts with great scepticism and suspicion, fearing the presence of audio information would disrupt, distract from and undermine the importance of the visual information on the screen, which they felt was the essence of all genuine cinema. However, audiences quickly embraced films with audio. After being once exposed to the new system, silent films seemed archaic and lacking in realism, and few found silent films to have continuing interest.

It is worth noting that even during the heyday of the silent film era, few audiences actually experienced them as completely silent. In most “silent” film
theatres, a carefully crafted musical score was played by a live organist. The music was intentionally synchronized with the imagery on the screen. It was carefully composed and played to accentuate the on-screen action, change with the mood and tempo of on-screen events, and to foreshadow dangerous developments or dramatic scenes. Most of these techniques for the use of sound in “silent” movies were subsequently transferred to the talkies, and are still used in contemporary cinema, television productions, as well as in computer games. (Bardeche & Brasillach, 1938, p. 60)

It was obvious to many during the early decades of the twentieth century that audiovisual technology still possessed considerable untapped potential, and interest in exploiting such potential was not limited to the entertainment industry. For example, the military was quick to realize such technology had possible uses for their purposes, and some of their early explorations of its potential have had long lasting effects.

For instance, much of what would eventually evolve into computer graphics, video and computer games, virtual reality and related technologies began with efforts to create flight simulators. Aircraft, particularly military aircraft, have always been very expensive. Good pilots have always been in short supply, and the training of a pilot is a difficult, dangerous and expensive process. Loss of an aircraft meant the loss of many hundreds of thousands of dollars worth of equipment, probably failure of a strategic military mission, the loss of the pilot, and probably a crew along with him. The same was also true of civilian
flights, in which one air crash took down not only an aircraft, pilot and crew, but also usually several dozen passengers as well.

The loss of even one aircraft was a serious matter, and most of these losses were deemed due to pilot error. Most such errors were deemed avoidable. They were generally due to the failure of reflexes at a crucial moment or a single incorrect split-second decision when the pilot was faced with an unfamiliar dangerous situation. Many of these disasters were potentially simple to avoid, but the only way a pilot could learn the needed manoeuvre was by successfully confronting the situation in real life. The problem, of course, was that those initial encounters with the unfamiliar situation that might have yielded the necessary experience if dealt with successfully generally proved fatal if dealt with unsuccessfully. No amount of book learning or instruction by seasoned pilots seemed to remedy the situation.

Thus, a great deal of effort was devoted to discover ways to simulate these potentially dangerous situations in a way that was not actually dangerous, but was nevertheless somehow realistic enough to engage the reflexes of the trainee in a way that would transfer to real-life flying experiences. Much thinking was done regarding the subjects we have referred to as immersion and engagement. How could training sessions be made as realistic as possible? How could they be made to simulate feelings of real motion and trigger reflexes in ways as similar to real life situations as possible?
Shortly after the World War I era, various clever contraptions were created using films of flight and landing projected on to screens in front of stationary pilots (Pimentel & Teixeira, 1993, p. 33-35).

These devices were later elaborated using some of the earliest television cameras trained on small models of airports, runways and aircraft carriers. The cameras were arranged so they moved in response to the movements of the controls initiated by the trainees, which in turn lead to changes in the perspective and image which appeared in front of the trainee (Pimentel & Teixeira, 1993). A great deal of money and engineering talent was expended on this endeavour, with at least marginally positive results. Even so, pilots continually reported these contraptions created little sense of sensory immersion, engagement or suspension of disbelief, and without at least a partial feeling they were really flying, the type of connection with their reflexes that would have improved the training effect largely remained elusive.

There were, however, a few notable discoveries about how to create immersive experiences during this era. For instance, it was observed that the feeling of forward motion was actually created more by objects moving in the correct way in the trainees’ peripheral vision, rather than the objects approaching from straight ahead (Braunstein, 1976). This was a counterintuitive finding, but it seemed to be consistent. Pilots reported the silence of simulated flight experience contributed to the sense of unreality, so the addition of sound effects, such as hum of the engines or sounds of other planes passing were added (Grosveld,
Researchers seemed to have discovered fairly early that even the highest quality stereo sound available was not very good at creating a true sense of realism. Even the best efforts to manipulate and reproduce the differential delay of sounds between the two ears and differences in the amplitude between the two ears simply could not create what pilot trainees said felt like a realistic reproduction of the sounds experienced in a real flight. If anything, the sound effects were confusing and disorienting, and may have detracted from the ability to suspend disbelief when using a flight simulator rather than add to it.

Considerable efforts were made to find ways of improving the audio in these flight simulators, but with only minimal success (Grosveld, 2001).

Slow but continued advancements in electronic computer technologies after the 1940s began to make it possible to have the images on the screen change dynamically in response to the pilot’s use of controls, and incremental increases the sense of realism were achieved. According to Pimentel & Teixeira computer programs were developed that could render rapidly-changing and somewhat realistic imagery in which visual objects were created out of a vast number of very small “polygons,” which could be endlessly “painted” by the system - configured and reconfigured in response to what the situation called for:

“The Navy discovered that the complexity of a scene (determined by the number of polygons) and texturing... was crucial in providing adequate velocity and altitude cues for line ups and landings on both airfields and aircraft carriers. The Advanced Development Model also showed that simulation of haze significantly contributed to the realism of the experience. Generally, the more realistic the image, the better the training.”
Just to prove that there’s an exception to any rule, they also noticed that pilots were having difficulties orienting themselves with respect to the featureless surface of the ocean. Their solution was to draw a checkerboard pattern on it to provide additional perspective cues - a good example of how decreasing realism can sometimes improve training effectiveness. (Pimentel & Teixeira, 1993, p. 34)

All of these considerations became dramatically magnified with the coming of the early space program. Each vehicle was now much more expensive. The speeds were much greater, the altitudes were higher, and the equipment went through more rapid innovations. Spilt-second decisions were more important, and the margin for error was much smaller. Loss of one space vehicle resulted in the loss of many millions of dollars, rather than thousands. The piloting of spacecraft was more demanding than that of an ordinary airplane, the requisite training more rigorous, and astronauts were even less expendable than good military pilots. During the 1950s, computer graphic technology continued to advance slowly, and the advances were quickly incorporated into the flight simulation programs. The military and NASA took this task very seriously, and spent a great deal of money on this enterprise throughout the 1950s and 1960s. Since most of the basic computer programs developed for these purposes involved flight simulation or aerial combat simulation, it is not a coincidence most of the computer games which appeared in subsequent decades were either flight simulation games or “shooter games” of one type or another.
The first serious efforts to merge video and computer technology into the types of 3-D Head-mounted displays (HMDs) now familiar as virtual reality were performed by Ivan Sutherland in 1966 while at the MIT’s Lincoln Laboratory. Sutherland’s device basically consisted of two television sets mounted within the helmet at either side of trainee’s head, with complex optical equipment projecting the images into the eyes of the trainee. A set of the highest quality stereo headphones were also incorporated. This system also included a very elaborate apparatus that measured the head position and head movements of the trainee, and fed this information into the computer. The computer would quickly re-render the artificially-created stereoscopic images and sounds so that they would closely match what the trainee should be seeing and hearing from the perspective of their current head position. Cables connected all of this equipment to the nearby computer, which took up an entire room. The equipment in the head mounted display was far too heavy for the trainee to support unaided, so the system was attached to the ceiling of the training facility. The highest quality stereo and computer-synthesized sound effects were also incorporated into the system. (Pimentel & Teixeira, 1993, p. 12, 33-35)

It was in the 1960s that most of what was later referred to as “virtual reality” came into existence. Efforts were made to feed computer-generated information into these head mounted displays in a way that created extreme sensory immersion and led to as high a level of imaginative immersion as possible. The concept was that the more fully such effect could be created, the
more realistic the simulation would be. The more real it “felt,” the more fully the
reflexes of the trainees would be engaged, and thus the more useful the
experience would be as preparation for “the real thing.”

Engineers soon determined that if the system did not update the images
sent to each eye at least 10-12 times per second, the experience was not of
realistic motion, but felt like a series of still shots that felt very unreal. Thus, as
the early cinematographers had discovered, frame rates of less than 10-12 per
second created no or apodicticity or imaginative immersion, but frame rates of
greater than 10-12 per second dramatically facilitated this effect. Two video
channels were used, one for each eye, in order to take full advantage of the
stereoscopic three-dimensional effects possible if a separate computer-generated
image was sent to each eye. Likewise, the systems were made to alter the image
in front of the trainees’ eyes to reflect they should see as they turned their heads.
This updating needed to happen very quickly to be effective. If the lag between
turning the head and the re-rendering of the point of view was more than about
50 milliseconds, it didn’t feel real. If the adjustment was too slow, the sensation
was as if the trainee had moved their head, and then the very disorienting
artificial image on the viewer was being moved to catch up with it. But if the
image responded appropriately in less than 50 milliseconds, the experience was
not of an image in a viewer being changed to follow head movements. Instead, it
seemed like a very natural sensation of seeing a real landscape, first from one
position, and then turning one’s head and seeing what was there in the visual
landscape to be seen from this new position. The experience felt very real, even though the trainee “knew” it was a simulation. In other words, a lag slower than 50 milliseconds did not encourage suspension of disbelief, but lags less than 50 milliseconds dramatically facilitated apodicticity, sensory immersion, or at least the partial feeling of reality.

Success in facilitating an experience approximating Ermi and Måyrå’s (2005) sensory immersion had now been more or less achieved in terms of the visual system, but little progress had made with the audio. Trainees still complained that the audio portions of the flight simulations did not seem realistic. In real life, pilots knew they could often determine the position of another nearby plane by hearing, even when they could not see it. They could accurately tell if it was above or below them, to the left or right, or behind them, how far away it was, how fast it was moving and whether it was advancing or receding. However, the audio portions of these simulations evoked little of these sensations. The engineers were now capable of precisely altering the relative delay of sounds reaching the two ears, and precisely controlling the relative amplitude differences between the two ears. They could now create an excellent sense of position in terms of objects to the right and left. However, no matter how hard they tried, they were not able to create any sense of sounds originating from above or below, behind or in front, nor any realistic sense of distance or proximity. The audio created by even the best stereo available was not engaging the pilot’s reflexes in the way that real sounds did.
Finally the researchers realized that ordinary stereo was incapable of producing such effects, and that some important aspect of the way the brain constructs a sense of directionality and spatiality had been overlooked. Since this unrealistic quality of the audio was perceived as the major obstacle to creating very realistic-seeming simulations, considerable attention and resources were devoted to the problem (Grosveld, 2001).

Throughout most of the twentieth century, the assumption among both the scientific community and audio industry was that a stereo system with a right and left channel which recreated differential delays and amplitude differences between the two ears captured and reproduced all there was to spatial perceptions. It was believed that all discriminations people were able to make in terms of the directionality and location of sound could be explained by these two factors, and the only significant improvements to audio realism and sound quality lay in reductions in the noise levels.

However, by the late 1970s, the perception within at least some sectors of the scientific community began to subtly shift, and there was an increasing awareness there might be more to spatial perception and audio realism than was being acknowledged. Shaw (1982) pointed out it was possible to make audio recordings which captured a much greater sense of directionality and spaciousness than did ordinary stereo. This technique was known as binaural audio (Gilkey & Anderson, 1997). This had been reported for decades, but had been considered little more than a curiosity and seldom considered as having
practical application. This recording technique, referred to as binaural sound, like stereo, involved the use to two microphones to record the sound. However, unlike stereo, binaural sound needed to be recorded by placing the two microphones at the sides of a human head, at the location of the ears. It was claimed that using very small microphones placed inside the ear canal of a human volunteer yielded an even better effect. The sounds were claimed to be much richer, fuller, and contained a startlingly realistic sense of distance and directionality.

Shaw (1982) verified that binaural recordings did indeed contain these additional qualities. For instance, people listening to binaural recordings made of a person ringing a bell while walking in a circle around the recording apparatus could accurately and reliably indicate the direction and position of the bell. They were able to determine not merely whether it was to the left or the right, but also whether it was behind them, below them or above them. This perception was often extremely accurate in terms of angle and approximate distance as well. Overall, these binaural recordings were dramatically more vivid and realistic than ordinary stereo effects could create. It was eventually found that recordings which included these characteristics could be made even when the two microphones were placed near the ears of an artificial but anatomically correct plastic head instead of a human head (Grosveld, 2001).

Why does this strange method work? What Shaw (1982) and other researchers discovered was that the human brain uses not only differential time
delays and differential amplitude cues to determine position and directionality, but also relies on differences in the power spectrum of the sounds. Sounds are very selectively filtered in terms of frequencies depending on which direction they originate from. For instance, sounds coming from above the person reflect off the top of the head and shoulders of the person, and various frequencies are thus absorbed or reflected differently than when the sound comes from below the person, and is thus not selectively reflected in this way. Likewise, the frequencies of sounds originating from behind a person are selectively filtered by the shape of the head, the pinna (outer ear) and shape of the ear canal differently than sounds originated from in front of the person (Vorlander, 2008). That being so, every direction has its own unique “signature” of frequencies that are consistently augmented or diminished as they arrive at the eardrum, and by analyzing the overall pattern of these frequencies, the brain is able to determine precisely which direction the sound probably emanated from.

Once this discovery had been made, this gave the NASA researchers and others the information they needed to create a very immersive and realistic audio system to match the visual channels of their virtual reality system. This approach turned out to be very fruitful. Eventually, they were able to create computer-programs that could selectively modify each computer-generated sound to precisely match the direction it was supposed to be coming from, taking into account the position of the trainee’s head to the origin of the sound. This led to the creation of computer systems in which the synthesized audio very
powerfully encouraged a kind of sensory immersion that felt very real. The location at which the object was represented auditorially could to be made to correspond with the position in which the object was visually represented as being, and this coordination created a remarkable experience of the object actually being at that location, even if the person “knew” it wasn’t really there (Grosveld, 2001).

Although NASA and the military never lost sight of the value of virtual reality in flight simulation, as this work advanced, there came to be a greater interest to discover what other uses this technology might have in areas not directly involved in flight simulation, such as the training of soldiers in other kinds of military manoeuvres on the ground or at sea. Possibilities of using it for training of technicians and other civilian types of education were also considered. Pimentel and Teixeira (1993, p.150-154) describe much of the early work in virtual reality. Engineers such as Mark Bolas experimented with all types of variations in virtual worlds to see which ones people actually liked, and what factors consistently increased immersion and engagement. Most of his early attempts were basically worlds in which rooms, buildings and walls were highly abstract drawings, with the walls consisting only of abstract line drawings. He had assumed that being able to fill them in, making the walls look solid and opaque like real walls would increase the sense of realism and therefore immersion and engagement. However, much to his surprise, he found the
opposite seemed to be true. People liked the solid, coloured, opaque walls less than the transparent abstract walls:

"The coloured wall might be more realistic, but the see-through boundary lines were more useful and enjoyable for certain tasks. And by leaving the world more abstract, versus building in more realism, Mark could draw users deeper in. (p. 152)"

Bolas concluded that despite the efforts of designers of flight simulators and other virtual environments to make computer generated images and simulations as realistic as possible, often the increased visual realism did not help, and was sometimes counterproductive.

The Pimentel and Teixeira remark that of all the variations and features that Bolas incorporated into his experimental worlds, one of the most successful attempts involved the addition of sound. This world included a virtual Theremin, an electronic musical instrument that allowed participants to alter the volume and pitch of the sounds by waving their hands about in various ways. This was a fairly simple and basic modification, but something about the mere addition of interesting audio to the virtual environment seemed to greatly enhance the immersion and engagement, even more so than major enhancements of the visual realism, such as adding colour to the imagery. This observation is still largely ignored even among many professional game designers (Pimentel & Teixeiria, 1993).
2.7 THE ROLE OF GESTALT THEORY IN IMMERSION & ENGAGEMENT

Gestalt theory addresses the possible enhancement of immersion and engagement through ambient sound. Gestalt theory posits the brain is wired in a manner that prefers to perceive information as whole patterns rather than as individual parts. Perceptual processes operate with a strong bias towards discovering patterns, even to the point of fabricating the illusion of a cohesive pattern when no such pattern actually exists. The primary focus of gestalt theorists has historically been on visual perception, but such research as has been done on music and “sonic gestalt” suggest the same basic principles also apply to auditory perception (Chion, 1994).

The concept of “sonic gestalt” can be used to address concepts related to the animation of sounds and the integration of sound with other sensory modalities such as vision. Specifically, gestalt theory refers to the psychological phenomena of: continuance, grouping, common fate, proximity, similarity and closure. However, in music there are additional components such as temporal animation, temporal linearization and vectorization towards a future expectation. Thus if a person hears the sound of a bird, they tend to associate the sound with nature, trees and the physicality of the bird. The person’s mind will likely anticipate seeing such additional objects as suggested by the sound even if they do not actually appear. The mind has a tendency to fill in and supply the “missing” details, and may even remember the event as if those elements had been present even though they were never actually seen.

Another term that can be understood in the context of gestalt principles
is Chion’s sound “en creux” (sound in the gap) (Chion, p. 218). This refers to a spontaneous fusion of sound and image if they occur close together in time and space. This principle explains such phenomena as lip synching and ventriloquism, in which the mind seems to accept speech as emanating from an otherwise implausible source if the visual cues associated with that source are effectively synchronized with it, such as a puppet or cartoon figure whose mouth is moving. “Sound is a chameleon that allows for a juxtaposition between object and unrelated sounds. The mind has a way of accepting such sound/visual synchronization as authentic. In terms of gestalt theory, this would be considered an example of closure.” (p. 218)

2.8 COGNITIVE THEORIES

Let us now consider some of the experimental research and theoretical considerations relevant to this subject of suspension of disbelief, immersion and engagement.

2.8.1 DEPTH OF PROCESSING

One item that is often noted in the literature related to concepts such as immersion or engagement is what Craik and Lockhart (1972) refer to as the “level of processing effect,” or the “depth of processing effect.” In a typical demonstration of this effect, subjects will be asked to read through a list of words and count the number of occurrences of the letter “E” within each word. They are then given a second list of words, asked to read through it, but instead of
counting the number of Es, they are asked to decide whether the word represents something they personally like or not. Subjects do not report that performing one task feels like it is making them do more work than the other. Subjects are allowed the same amount of time for each list, and are not instructed to attempt remember the words.

However, a few minutes or hours later, the subjects would be asked to recall as many words from each list as possible. What invariably happens is they remember few (if any) of the words for which they only counted the number of Es, but remember a surprisingly large number of the words they had evaluated in terms of whether it represented something they liked or not. This effect is extremely robust, and leads to as much or more recall than if the participants are asked to mentally rehearse the lists or make other conscious attempts to remember as many of the words as possible.

What accounts for this effect? What is generally believed to be happening is that when evaluating words for whether they represent something the person likes or not, this engages the attentive and cognitive processes of the mind in a much fuller and deeper fashion than if they merely count the number of Es in the word. Forming even a quick judgment about whether a word represents something the participant likes or not must activate mental functions related to pain and pleasure, distaste and enjoyment as well as past experiences and memories related to the word and the object to which it refers. This must recruit mental processes of a highly emotional nature that consider the value,
importance and meaning of the word and its associations, personal implications and significance for the subject. By engaging the attentive and mental processes in this deeper way, this seems to automatically lead to greater retention and memory of the material. This greater retention apparently happens regardless of whether it was the intent of the participant to remember the material or not, and regardless of whether the person is aware their mind is recording the material more effectively or not.

Such a phenomenon may have implications for the addition of ambient sound to program material. This suggests that by making the material more engaging, various attentive processes or mental faculties will be activated in a more complete fashion, and that this might automatically make the material more memorable. This might be the case even when doing so does not necessarily seem to the participants as though they are concentrating more or are doing more cognitive work.

2.8.2 MEMORY LOCATION TECHNIQUE

There are other examples which at least indirectly suggest such an effect, some of which relate to what are called “mnemonic devices” - techniques intended to enhance memory. One such example concerns what is known as the “method of loci” (Yates, 1966). This method of loci (places) is the oldest recorded memory technique, believed to have been invented in sixth century B.C. Greece. It seems that a large building had collapsed, crushing the people within almost beyond recognition. However, as people were sifting through the rubble, one of
the few survivors of the disaster, a man named Simonides of Creos, was able to give an accurate accounting of which crushed body belonged to who. When Simonides was asked how he was able to offer such accurate information, he revealed he relied on his own memory of who had been sitting at each particular location just before the roof caved in. He merely had to mentally “walk through” his memory of being in the building and remember who had been seated at which spot. This incident and the formal application of its principles is believed to have been the origin of the method of loci.

In more contemporary use of this method, a subject attempts to memorize a list of words or other items by mentally placing each item at a specific along a familiar route. For instance, the first item may be mentally deposited on the sidewalk in front of the path leading up to the front door of their home, the second item set upon the front porch, and the third against the front door itself. After each item has been mentally deposited at its own location, in order to recall the list, the subject mentally retraces the route, stops at each location and observes what is there. Thus they find the first item on the sidewalk, the second on the porch, the third against the front door. As esoteric as the description of this technique may seem, centuries of use by orators and students, as well as decades of empirical investigation, have verified it is remarkable effective in practice (Yates, 1966).

Numerous researchers have attempted to explain why this method works (O’Keefe & Nadel, 1978). The general explanation seems to be that the brain’s
normal method of remembering information is to create and store it in the form of mental maps. Therefore, a good way to make information more memorable is to fit it into a mental map. This seems to work even if the material is new and unfamiliar, or the mental map is comprised of surreal details and unrealistic content. Something about the intentional formation of a visual image related to an item a person wishes to remember, combined with the incorporation of that visual image into a specific spatial position within a mental map makes it much more memorable.

The formation of a visual image related to the relevant item seems to be a key factor for increasing the likelihood it will be remembered later. For instance, even without deliberate use of the method of loci, if instead of simply mentally repeating the word “cat” or “bee” several times internally or trying very hard to remember it, if the subject forms a mental image of a cat or a bee, this will greatly increase the subsequent memory of the word (Atwood, 1989). Furthermore, this same method also seems to work much better than merely placing a mental picture of the written word cat or bee at the specific location when a person does use the method of loci.

Where this becomes relevant to ambient sound is that it has also been noted that when using the mnemonic techniques, if instead of only forming a visual image associated with the word, the person also mentally adds a non-verbal sound as well, this further enhances the memory of the item. For instance, a person would mentally rehearse the word “cat,” form an image of a cat, and
also include a short segment of mental audio in which the cat was purring or making some other cat-related sound. When the word “bee” was encountered on the list, the subject would form a visual image of a bee, along with a humming sound (Sternberg, 2008). Considering what has been previously said about increasing the engagement of the mind with the material to be learned serving to facilitate learning and memory, perhaps this finding should not be particularly surprising.

2.8.3 DUAL CODING THEORY

There are a number of other theoretical claims which suggest adding auditory information (or other sensory information) to an information stream improves attention and memory for that information. Much of this is related to what has been called dual-coding theory (DCT) and has followed the ideas of Paivio (1986), who maintains that in addition to more familiar verbal/semantic channel of information processing, humans also possess one or more separate non-verbal or “imaginal” channels, and each channel processes information and stores memory in its own distinct way. Most of the research and arguments in this area have been focused on efforts to demonstrate that memory of visual images is probably very distinct from that of verbal information. But as Jones et al. (2005) point out, the same basic theory and observations are equally applicable to all the other senses as well. There are probably channels that process and store not only visual images, but also channels that process and store non-verbal auditory information, kinesthetic, olfactory and taste information in a manner
that is much more like an “image” than merely a verbal description of the information.

Jones et al. (2005) have performed a variety of experiments they claim demonstrate not only the existence of a haptic (touch) “image” form of information processing and memory, but also that the addition of such haptic information to the learning of complex material can dramatically improve comprehension and memory of that material. For instance, Jones et al. showed that by adding a touch dimension to a complex multimedia demonstration about viruses and how they interact with cells dramatically improved not only the interest level of students but also understanding and memory. By creating and exposing the students to a complex computer interface which allows them to “get a feel” for the shape and movement of the virus, entities ordinarily far too small to be seen and difficult to conceptualize, doing so increased memory and interest in the subject considerably beyond what a purely visual and verbal presentation was able to do.

2.8.4 COGNITIVE LOAD THEORY

A related theory is referred to as cognitive load theory (Sweller, 1994). This is based on the assumption of not only the existence of various non-verbal imaging systems for each major sense, but also includes the assumption each of these memory stores has a limited capacity. If information is presented in a way that exclusively focuses upon only one system, this will tend to overwork, overload and fatigue that system. However, if the information is presented in a
manner that activates and can be at least partially processed by two or more modalities, the multiple systems can share the work, and the cognitive load on any particular system in reduced (Mousavi et al., 1995). Analogous to having two or more people carry a heavy object instead of just one, such distributed processing makes the task easier. Such a theory implies that understanding and memory of a presentation will be much more effective if the information is presented in such a way that activates two or more processing modalities rather than just one. Verbal plus visual will be better than either verbal or visual alone, and verbal plus visual plus audio should be superior to either verbal or visual alone, or even both of them together.

As we have seen, research into mnemonic techniques has also demonstrated the use of multi-sensory information in the imagery significantly increases recall. All of these observations are consistent with dual trace theory and with cognitive load theory.

2.8.5 MULTIMEDIA LEARNING

People will learn better from information presented in both written words and pictures because information comes in through two channels, and the information in each channel is processed separately, resulting in a dual channel processing which is more efficient than single channel processing. Effective multimedia learning results from learning materials that are designed to include both pictures and words to engage both processing channels (Mayer, 2005).
2.8.6 MEMORY TRACES

Another set of theories claim new information is better comprehended and better learned when relevant existing memory traces stored within long term memory are activated. Thus, if the new incoming information can be connected with existing memory traces, better learning occurs both because fewer new memory traces need to be constructed and more retrieval paths will exist between existing memory and the new information (Kieras, 1978). In this way, the new information is more easily assigned a relevant context in long-term memory and thus more readily assimilated (Atwood, 1989). The greater the extent to which new information is linked with material already encoded and stored within existing memory, the more extensive, richer and interconnected will be the new memory traces (Fisher & Craik, 1980). The more extensive these new traces are, the more readily they can be retrieved, and thus the better will be recall and recognition for this material. According to this type of formulation, a memory trace consisting of verbal, visual and auditory information should be more extensive and therefore easier to find and retrieve than a trace consisting of verbal information alone. This is because in some sense because a multi-sensory trace is “larger” than a single-sensory trace, and because a multi-sensory trace can be accessed by multiple retrieval pathways, not just one.

Mental imagery processing is not one-dimensional. Ellen and Bone (1991) reviewed the imagery literature and found that quantity of images, ease of
imagery activation, and vividness of imagery are distinct dimensions of imagery processing. These dimensions of imagery processing can be viewed in terms of the model presented by Kieras (1978). Kieras implies memory traces carrying more concrete information are more elaborately encoded within semantic memory and are therefore more readily learned and retrieved. According to such a formulation, the addition of rich auditory information to the message should make it more memorable.

2.8.7 EVOKING EMOTION

Another set of theories maintains the evoking of emotion is a very important factor for learning, memory and attitude change. It has been noted the mental images evoked by stimuli vary in the degree to which they are affect-laden. Some images tend to evoke strong emotion while others do not. It seems that images which evoke stronger emotional responses are considerably more memorable than those which evoke weaker emotional responses (Sheikh & Jordan, 1983). Images that evoke stronger emotional responses are probably more richly interconnected with past experiences and their associated emotional reactions and emotions stored within long term memory (Lang, 1979). If so, then we would expect stimuli that produce more vivid imagery should produce stronger feelings than should low-image stimuli.

The implication of this is that educational programs which include imagery-producing sound effects might create stronger kinesthetic reactions than will the same educational materials without imagery-producing sound effects. If
they are better able to evoke kinesthetic reactions, they should be remembered better. The potential being that imagery producing sound could create better learning outcomes through related memories and strengthening the cognitive processes involving multimodal processing.

2.9 PRACTICAL IMPLEMENTATION OF AMBIENT SOUND

Ambient sound is background sound that is provided by the “natural” environment. The following is a description of the way the importance of ambient sound is explained for students and professionals in the cinema industry:

"If this sound were not present in the projection of a particular scene -- specifically a scene in which the only sound is dialogue - the scene would sound hollow and empty to the audience. The environmental noises can be recorded by a separate microphone during filming or in fact may be added by the foley artists in the remix of the scene. (Film Studies Glossary, 2006).

Chion (1994) describes ambient sound as “sound that envelops a scene and inhabits its space, without raising the question of the identification or visual embodiment of its source” (p. 75). This poetic description is a good place to begin a discussion of ambient sound and interactivity. Ambient sound provides continuity between shots within a scene. With regard to interactivity, it also helps to “suture” together disparate interactive elements to create a cohesive whole. It can lead a participant to deeper connection to the content, and, if well done, it can create in the person a sense of immersion and engagement."
Given the material presented thus far, it seems there is reason to suspect the addition of ambient sounds to a presentation would enhance the learning and memory of material presented within it. We have claims by technologists from as far back as Thomas Edison who believed the sound track was the more important half of a motion picture, and the claims of Mark Bolas who clearly reported the addition of non-verbal audio made virtual reality presentations much more interesting. In addition, we have several respected theorists (Paivio, 1986; Sweller, 1994), who explain why the addition of such sounds should improve learning. However, even the opinion of technologists as illustrious as Edison does not prove the claim is true. Bolas only was able to document that people found virtual environments with non-verbal sounds more interesting and engaging than those without, but this is not quite the same as proving ambient sounds led to improved learning and memory. As for the theorists, a plausible theory is not the same as an empirical test.

Despite the suggestive and theoretical evidence, in current practice, surprisingly few producers of educational and training software seem to be using ambient sounds. In a recent study (Barrons & Calandra, 2003), which included the products from nine prominent educational software producers, all advertised their use of both visual and audio information. Such claims feature very prominently in the advertising of such products, and the companies seem to make every effort to make sure potential purchasers are aware the product includes both visual and audio information. Although these are technically
accurate claims, in practical terms what they meant was they all included a redundant spoken verbal sound track which essentially read the on-screen text aloud for the user. This is an important issue because when the various theorists mentioned in the previous section claimed the inclusion of visual information to an otherwise completely linguistic information stream was a way to dramatically improve learning, they were referring to the addition of pictorial information and non-verbal imagery, not written words. Likewise, when such researchers claimed the addition of auditory information should facilitate learning, what they were referring to was the addition of non-verbal aspects of the audio, not the addition of redundant spoken verbal information. At least from the theoretical perspectives of Atwood (1989), Paivio (1986) and Sweller (1994), simply adding spoken words to the already existing visual text (or adding written words to a spoken narrative) should not be expected to lead to any significant facilitation of learning and memory.

Beyond this redundant use of spoken verbal information, few if any of these software creators utilized much other audio information. A full 50% of them reported never or almost never even using any music in their programs. Even when they did make sparing use of music, it was invariably used in short segments at the introduction or completion of a program or to signal the transition between one segment of the program and the next, but not otherwise integrated into the content. Only 32% of the software producers interviewed by Barrons and Calandra made use of significant non-verbal sound effects other
than music, and even these instances seem to have been very rare and limited. They seemed to have resorted to sound effects only when doing so was absolutely unavoidable. Such sounds were used, for instance, when the purpose of the training course was to teach naval trainees to discriminate between certain kinds of sonar signals, to teach medical students to distinguish between the sound of healthy and unhealthy heartbeats, or when the programs were intended for use by visually impaired or non-literate students (Beecue et al., 2001).

A somewhat more recent survey of educational software and e-learning materials (Calandra et al., 2008) revealed essentially the same pattern. The producers of such materials still rarely if ever incorporated ambient sounds into their content, and even when they did, such uses tend to be very minor and employed only for brief isolated segments of the content rather than extensively throughout the entire program.

This implies contemporary e-learning designers do not consider the use of audio to be a priority and don’t make a budget for it. Puzzled by this observation, Calandra et al., (2008) asked a set of questions about the designer’s motives for using or not using sound. Rather than referring to any kind of technical or corporate guidelines, or raising any budgetary, technological, or even theoretical considerations for their use and non-use of audio their programs, the most common answer was “intuitive rationale.” By intuitive rationale, what seems to have been meant was the designers were relying upon their own subjective feelings, assumptions or intuitions about whether the use of
sound in a particular instance would enhance or interfere with the desired educational effect. The general picture presented by these two studies is that contemporary software designers and programmers as a group operate from a set of assumptions and beliefs which tell them audio is not very important or useful.

Given the previously cited information from media engineers, inventors, technologists, experimenters, theorists and others about the alleged beneficial effects of audio information, it is somewhat surprising so many contemporary educational media designers assign such a low priority to ambient sound. Perhaps if we examine some additional research by others who have attempted to make practical use of ambient sound in related contexts, the possible reasons for such an attitude may become clearer.

Based on empirical tests, Marks (1992) reported the use of ambient sound in radio commercials generally increased learning of product information, memorability of the message and improved attitudes toward the brand. This effect was quite robust, relatively easy to create and inexpensive to implement. Based solely on these results, one might assume all educators, advertisers and politicians would want to use ambient sound in all of their communications, and that they undermine their own effectiveness if they fail to do so.

However, the situation is not quite that simple, for Marks also described a case in which the use of vivid and realistic audio effects was counterproductive. This was a case of a tire commercial in which realistic sound effects of an
automobile crash were used. The intent was to emphasize the importance of safe
tires for protecting one’s self and loved ones. It was not entirely clear what
happened, but the presence of the sound effects had an entirely negative effect.
Marks speculated either the vividness of sound evoked anxiety and negative
feelings which then transferred to tire brand, or that the sounds triggered strong
personal memories of automobile accidents and the resulting negative emotions
disrupted reception and memory of the factual information. This pattern may be
relevant to anyone hoping to use ambient sounds in materials intended to
activate negative emotions to get a point across, as many commercials and
communications of a social, political or educational nature are intended to do.

This example also points out the use of audio is not a one-dimensional
variable. Subtleties about the interaction of the specific sound effects, emotional
responses, factual information and the personal history of the listener can be of
considerable significance.

Studies such as those described by Marks (1992) used ambient sound as
background information to reinforce verbal messages as typically used in radio
 commercials, television advertisements, and computer games, but more
sophisticated uses of such sounds are also possible.

Mayer and Moreno (1998) discussed the design principles that stem from
theorists such as of Paivio (1986) and Sweller (1994). They note that adding
redundant written words visually in a multimedia presentation rather than
merely presenting them as verbal audio narration seems to substantially interfere
with learning. The explanation seems to be such visual addition of words tends to overload the verbal processing system, (and probably the visual system as well). The simultaneous use of visual words seems to compete with and interfere with the verbally presented information leading to less, rather than more learning.

However, the initial lower level reception and elementary processing of words does require the use of the auditory or visual intelligence systems, so what happens with these other channels is not necessarily irrelevant to the comprehension of linguistic material. If these other channels are required to do other work, such as process visuals, use physical motions, or process non-verbal sounds, might this somehow interfere with a person’s overall ability to process verbal information? Might the use of ambient sound overload the auditory system, which is necessary to process the basic sensory components of spoken verbal narrative, or compete with the linguistic/semantic system’s ability to receive verbal information, process and remember it?

Mayer and Moreno (1998) also at least indirectly address a similar issue. They refer to this as the coherence principle:

"students learn better from a coherent summary which highlights the relevant words and pictures than from a longer version of summary...students who read a passage explaining the steps in how lightning forms along with corresponding illustrations generated 50% more useful solutions on a subsequent problem solving transfer test than did students who read the same information with additional details inserted in the material."
This issue is an important one. It is generally assumed the richer, more realistic and more immersive the material is, the more interesting and engaging it will be, and therefore the more learning will take place. However, this passage raises an interesting issue that may also apply to ambient sound. Is it possible that by adding rich ambient sounds that are not absolutely essential to communication of the material, the richer, more salient and engaging they are, the more they will distract and detract from learning? Perhaps the students will enjoy it more and find it more interesting and engaging, but learn less from it?

This is the same issue that has been encountered by commercials which rely on very funny comedians or glamorous, scantily-clad models to help sell their products. The inclusion of such persons in the commercials unquestionably attracts more attention and makes them more entertaining and memorable. However, it does not necessarily sell more products. This seems to be because all the attention is attracted to the comedian or the model, rather than to the message or the product information. It is therefore the comedian or the model that is remembered, not the message or the product. Perhaps by the addition of such vivid sounds, we might actually be defeating the purposes of enhanced learning. (Bobis et al. 1993) raise the same basic issue.

A related issue is raised by the examination of another interesting use of ambient sound to enhance the learning process for children described by Rogers et al. (2004). In a study entitled, Ambient Wood: Designing New Forms of Digital Augmentation for Learning Outdoors, the authors describe the use of ambient
sounds to enhance the children’s response to an outdoor educational setting created to help teach them about a natural woodland environment. Numerous electronic devices had been incorporated into the site, with which the children could interact in various ways. For instance, the students carried PDAs with them, through which they received information at strategic times and locations about various features and detail of the ecology. Information about the sounds made by various birds or insects could be played to give the children instructions about what to listen for and the significance of such sounds. In some cases, the children failed to distinguish the electronic sounds from the real ones, or they were distracted from the sounds by the wealth of information from other channels. Such issues sometimes seemed to interfere with the effectiveness of the lessons. In another example, the process of “root uptake” was represented auditorially for the children. The authors do not provide much detail about how such abstract processes and concepts were represented with sounds, but the technique nevertheless reportedly worked fairly well.

Although not every innovative use of ambient sound attempted by Rogers et al. (2004) was successful, at least some of them were. In a few cases, the ambient sounds were apparently distracting or confusing, overall the authors reported the addition of ambient sound to be a valuable tool for learning enhancement.

Hede (2002) summed up the problem as follows:
The debate surrounding the issue of whether auditory instruction helps or hinders learning is ongoing, largely because of a myriad of contingent factors that have been shown to moderate multimedia effects (p. 177).

Hede is here discussing the more general issue of the use of auditory information in educational media, which of course includes a much broader category of sounds in addition to ambient sounds. Nevertheless, this issue Hede raises may apply to the use of ambient sound as well. Perhaps it is more useful in some circumstances than others, and perhaps there are a variety of factors which may increase or decrease its value in a particular case, setting or circumstance. At present, little knowledge exists about what those contingent factors, appropriate contexts and mitigating circumstances might be.

As it stands, there are some studies which seem to suggest ambient sound might turn out to be distracting and counterproductive to learning, while others indicate it is useful and valuable. The matter seems to come down to a simple question: Does the inclusion of ambient sounds improve the learning of complex information, or does it not? This matter has not been resolved by existing studies. More research is necessary, since the role ambient sound plays in educational multimedia is not fully understood and may never be fully addressed since it is so dependent on interplaying factors. As has been discussed previously, the appreciation of the importance of sound within the mainstream of the film industry took a surprisingly long time. The road to full appreciation and understanding of how ambient sound may contribute to educational e-learning and multimedia application may also turn out to be a very long road.
CHAPTER 3: RATIONALE, ASSUMPTIONS & PRINCIPLES

"When most successful, design creates an experience that is both delightful and relevant to the human being. (Rhea, 2000)

This chapter contains a description and discussion of the theoretical and practical considerations which informed the design of the Towards Utopia research instrument.

A major philosophical influence on the design of the research instrument for this project was the concepts of Richard Buchanan. In Good Design in the Digital Age, Buchanan (2000) sets out to reflect on what “Good Design” means for electronic and digital media. He begins by asking, “What is design?” and then, more importantly, “What is good design?” In Buchanan’s opinion, since the 1950s, good design has been defined as “displaying qualities of beauty as well as functional clarity and efficiency.” Many believe the role of design is to provide decoration or visual style to an object. However, according to Buchanan, this is an error, since design is not a trivial aspect of the development of information technologies.

Buchanan (2000) poses questions to ask in relation to digital content: “What is its intended use?” and, “What is it useful for in my life?” He looks for
content and purpose, with the hope that the content will be designed with thought given to effectiveness and clarity, the goal being to create a useful product that performs its function well. He adds that what designers can offer the production team is “a significant measure of common sense - sometimes lacking in content experts who know their subject matter but do not know how to present its logic to an ordinary human being” (p. 3).

A key function of good design is ease of navigation - allowing people to explore the interface with confidence and to experience a level of “accomplishment and satisfaction.” Buchanan adds that designers focus on something that technical experts may ignore: “the ability to bring grace and elegance into forms and devices that are humanly engaging, often exciting and sometimes unexpected.” Designers “add marvel,” he says, and make the products more useable, and that usability is very important in an encounter with new technology.

Buchanan also suggests a third important question: “Do I really want to explore this product?” This is a personal-choice question, and it plays on the desirability of a product, that is, human desire involved in selection. Most people think of these as marketing issues, and at superficial level, they are. However, in Buchanan’s thinking, designers also give “voice” to the product. Voice comes from the combination of the three qualities of “usefulness, usability and desirability,” the fundamentals of good design. When creating the interface for

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this project, I wanted to incorporate Buchanan’s philosophy of “Good Design,” to
guide the direction of my design.

3.1 HUMANIZING KNOWLEDGE: RICHER LEARNING, DEEPER LEARNING

"An interface is humane if it is responsive to human needs and considerate of human frailties... you must cultivate in yourself sensitivity to the difficulties that people experience. That is not necessarily a simple undertaking. (Raskin, 2000, p. 6)

A second philosophical influence is the work of Raskin (2000), who was the inventor of the one-button mouse and a key player during the early years of Apple Computer®. Raskin made a major contribution to HCI (Human-Computer Interaction) by making simplicity the primary goal in design. Raskin states that consideration for the end user should be the primary focus for the interface designer. He insists on the importance of keeping the end user in mind during the design of interface systems, and designing in such a way that the cognitive processes of the user drive the design process. Following Raskin, a central priority in the design of the Towards Utopia research instrument was concern for achieving simplicity in design – both sound and visuals – and accommodating the cognitive processes of children. Raskin (2002) created a framework for designing humane interfaces. The basics of his design heuristics and its principles are summarized as follows:

The first principle: When designing a product, design it in such a ways as to help people perform a task, but never distract people from the task at hand. An interface should be habituating. If an interface is used frequently, many tasks
become automatic. Therefore, the use can change their loci of attention. The goal of design is to make as much of the interface habituating, while avoiding repetitive modes of operation, and have only one operation for any particular task.

The second principle is that a system should have reliability and not allow work to be lost: “The system should treat all user input as sacred” (Raskin, 2002).

The third principle is that an interface should be as efficient and as simple as possible: “A computer shall not waste your time or require you to do more than is strictly necessary” (Raskin, 2002). The interface is the most important experience in the design and should be noticed the least.

Another principle is that the design of an interface should be visually attractive and pleasant to use: “Once a product’s task is known, design the interface first; then implement to the interface design” (Raskin, 2002). Task completion should be the primary goal, but the overall design should be attractive as well as effective, habituating, reliable, efficient, and well tested.

### 3.2 TANGIBLE USER INTERFACES

Tangible computing is a branch of computer science that deals with user interfaces called TUIs (Tangible User Interfaces), with which a person physically interacts through a wider range of movements than is afforded with traditional interfaces. Tangible computing involves direct physical manipulation of digital information. The physical elements control the interactivity and are coupled to digital content (Ishii & Ullmer, 1997).
The *Towards Utopia* prototype combines the benefits of interactive multimedia with the intention of allowing children to learn through a wider range of activity using computation objects than is ordinarily possible with conventional interfaces. As discussed in the previous chapter, several prominent cognitive theories such as dual channel processing strongly imply multi-channel sensory input should lead to enhanced learning, memory and understanding. If only visual information is presented with no other modality, then only a limited amount of information is likely to be remembered. However, if information is presented though multiple modalities, it is possible a greater amount of knowledge may be transferred to long-term memory.

We do not yet fully understand how the addition of haptic information is processed or how it supplements or competes with visual information stored in the so-called “visual-spatial sketch pad” (a hypothetical neurological module responsible for holding and processing visual-spatial information), and the articulatory or phonological loop (a hypothetical neurological module responsible for holding and processing auditory information) (Antle & Wise, 2010).

Although TUIs are not explicitly mentioned in Raskin’s theories, his heuristics are useful for the design of TUIs, for his concepts of interface designs encourage the creation of systems that are more humane. TUIs support a wider range of input actions than a traditional GUI (Graphical User Interface). This
may be beneficial for learning activities in which movement and physical operations on objects are integral to learning.

When working with a TUI, the user is supported to “live in their body,” so to speak, even if the user’s awareness is not focused upon their kinesthetic sensations. For children, supporting physical activity in some learning tasks may improve concentration and engagement with the task at hand. In this way TUIs may enable a richer experience and deepen the learning potential.

There are three modalities for learning: auditory, visual and kinesthetic. An individual's modality strength can best be described as the sensory channel through which they process information most efficiently (Tanner & Allen, 2004). Most people use a combination of modalities, but generally there is a preference for one particular learning style. Visual learners learn best by seeing demonstrations and being shown pictures. Auditory learners learn best by listening. Kinesthetic learners learn best by physically doing something. They require movement in order to better understand information presented to them. A tactile – physical style of learning is preferred by kinesthetic learners since they retain and understand information better if they can physically explore (touch, play with, interact with) the objects they are learning about. Learning activities that require hands-on work are best suited for the kinesthetic learner.

In addition, it is estimated that about 15%-40% (Lambert, 2004, p. 76) of the population are kinesthetic learners. Kinesthetic learners learn better when they can physically manipulate what they are learning (Brostick, McCready &
Nipper, 1988 p. 51). If approximately 40% of young children are physical learners, this suggests a vast amount of learning potential remains untapped by the mainstream educational system. TUIs allow for physical interaction that would appeal to the kinesthetic learner.

A major assumption which strongly influenced the design of the interface was that, consistent with the findings of Jones et al. (2005), discussed in the previous chapter, one of the ways children learn is tactiley, and learning can be improved by presenting information to children in a way that is more kinesthetic, and thus enjoyable. The haptic nature of TUIs allows children to explore the interface and engage on a deeper level with the content.

Following the theories of these learning modalities, and the example of Jones et al. (2005), it was decided to make the interface as tactile, kinesthetic and movement-oriented as possible by building in important tasks for the children to do that involved more motion than the minor wrist movements required by an ordinary mouse or the buttons of a game console.

Children are natural explorers. They learn about the world in a physical way. This process begins before a child is born and continues throughout childhood. Once out of the womb, they begin by putting things in their mouths to explore texture, taste and physical composition. I believe traditional classroom education can limit a child’s ability to learn in a hands-on, tangible way. When children enter school, they suddenly find a curriculum imposed upon them that is contrary to their natural, physical way of learning and confines them to a desk.
Information is then presented to them in a physically passive way, either on a computer or on paper. One of the goals of this thesis is to help children recapture what I believe to be a more natural, more physical way of learning that benefits all styles of learning. I believe tangible tabletop interfaces provide a tactile medium for all children to explore, allowing them to “live inside their bodies” once again.

### 3.3 RESEARCH INSTRUMENT CONTENT CHOICE

In order to get to the research question content needed to be developed for the project. Therefore, the content needed could not be a repetition of material covered in BC school classrooms, but needed to still be interesting enough for the children to learn. Of note is the lack of content surrounding sustainability in British Columbia school curricula. In British Columbia, environmental education classes are taught on an ad-hoc basis, and are left largely to the discretion of the classroom teacher (Waterman, 2009, personal communication). Based on the notion that children are natural physical explorers, and the education system in British Columbia seems deficient in environmental education, the decision was made to design a tabletop interface to teach concepts surrounding sustainability.
3.4 TARGET DEMOGRAPHIC

In order to optimize learning outcomes, it was very important to discover exactly which age group would be most appropriate to focus upon in this experiment. For maximum learning benefits, distinct styles of education can be matched to children at specific ages.

In *EcoKids: Fostering Sustainable Behaviour*, McKenzie-Mohr (1999) describes the best time to begin to encourage ecologically sustainable behaviour in children:

"At this age 7-10 children start to discover self. They begin to feel a connection to a larger community, and are naturally inclined toward wanting to save the world. As their ability to engage in abstract thought emerges they can begin to understand environmental problems.

Mohr goes on to state:

"It is my opinion that children in the 8-12 age group can easily grasp the threat some human activities pose to the environment. Although they may not understand global warming and its vast impacts, or the chemistry of ozone depletion, they can easily understand how pesticides and habitat loss impact wildlife. They can also understand other issues on a more general level. (p. 46)

Following the claims of Mohr, it would seem that children in the range of approximately 8-12 years would benefit most from the interactive experience intended to be created for this research project."
In The Child’s Conception of Physical Causality, Jean Piaget (1930) discusses different stages of development. He suggests that between the ages of seven and eight a child begins to develop the ability to appreciate concerns greater than themselves, and begins to become conscious of their own subjectivity.

A progressive separation of the outer from the inner world, and progressive reduction of the adherences, in brief, are the two fundamental aspects of the first process which we defined as a passage from realism to objectivity.... The second characteristic process in the evolution of the idea of reality is the passage from realism to reciprocity. This formula means that the child, after having regarded his own point of view as absolute, comes to discover that possibility of other points of view and to conceive of reality as constituted, no longer by what is immediately given, but by what is common to all points of view taken together. (p. 247)

Since the intent of this project was to include content related to sustainability issues, it was necessary for the learners to have an adequate social awareness of issues larger than themselves. This again suggests the age range of 7-8 years as the lower limit for participation in the study.

In Digital Storytelling: A Creator’s Guide to Interactive Entertainment, Miller (2008) points out that understanding the ramifications of the child’s age will help “inform the design process” when creating interactive media for children. She discusses the main considerations that should be explored during the design process. These include, but are not limited to: childhood development stages, gender, parental influence (desires/fears), and the desires and aspirations of the children. She also discusses what types of content will most strongly appeal to children of each group. Miller also defines what she refers to as “The Seven Death Kisses of Designing for Children” (p. 143). She also points out that children
today gravitate towards digital content, and, for the first time in history, children now spend more time with computers than watching television.

According to Miller (2008), multitasking is also now very common with children, and children can split their attention among several streams of information. Cross-entertainment opportunities are increasingly options for digital content. This cross-platform nature of the medium appeals to children. Interactive movies, smart toys, immersive environments (museum and parks) also appeal to children. Interactive content for children spans many media and products. To succeed, all these media require observance of universal principles, the most fundamental being to know as much as possible about your audience. This understanding acknowledges children have their own culture, identity, language and values, and their culture differs from that of adults. We need to understand these cultural and emotional differences to design effectively for children. The general age-groupings in Miller’s definition are: preschool/kindergarten (3-6), early elementary (5-8), upper elementary (7-12 [tweens]), and middle/high school (12+ [teens])(p. 142).

In addition, besides outlining the distinct age groupings, Miller (2008) points out that what appeals to girls will not necessarily appeal to boys, and vice versa. She also suggests using available guidance to define the suitability of content. For instance, she suggests seeking out developmental specialists and educational specialists, particularly specialists in developmental psychology. Miller suggests classic authors such as Piaget as well as more contemporary
scholars. Although Miller acknowledges it might not always be feasible to consult with a childhood psychologist, she advises against using only literature, and advocates instead speaking with professionals familiar with how people learn, such as classroom teachers.

Heeding this advice, for the purposes of this study, I invited an educational specialist to join the design team. I also included an instructional designer to assist with considerations about factors such as age appropriateness, pedagogy, and what the children themselves would likely to enjoy.

As defined by Piaget (1958) in his book The Growth of Logical Thinking from Childhood to Adolescence, the stages of childhood are: Toddlers — who love to experiment with objects; Children (2-7) — who are fascinated by symbols such as letters and numbers; Children (7-12) — who are trying out reasoning skills; and Teens (12+) — who are trying to understand abstract concepts and to test hypotheses. Piaget’s theories are relevant for interactive media since each phase of childhood has a preferred mode of play to exercise the mind and to challenge their increasingly sophisticated skills. Piaget qualifies these categories by stating that these preferences for learning are fluid. Toddlers might experiment with play characteristic of older children, and children that are older might still enjoy and be comforted by activities that are associated with an earlier stage of development. It is quite common for earlier play patterns to be incorporated into the current games of older children. Thus, a game for teenagers might incorporate all four play patterns.
Children's learning does not necessarily follow a straight line of progression. The progression is gradual, and leads a child to the ability to understand abstraction. It is this concept of abstraction I am particularly interested in. The idea is more clearly defined by Hetherington, Parke, and Otis Locke, (2006), in their book *Child Psychology: A Contemporary Viewpoint*. In the section on Piagetian theory, they state:

"Piaget uses the principle of adaptation to describe the process by which intellectual change occurs. As a child grows, he interacts with the world, and these interactions promote an increasingly more complex way of understanding that is adapted to the world in which the child lives and functions....(p. 12)"

Piaget has referred to schemata as symbolic representations that are assimilated within an intellectual framework. Complimentary schemata may be organized into a coherent structure or mental map. As such, they may be modified or replaced as more and more events and relationships are assimilated and acted upon, or as cognitive structuring becomes more advanced.

The general conclusion I reached from all of this material was that children between the ages of about seven and ten years of age were likely to be the most appropriate participants for this study, and the interface was developed with this consideration in mind.
All knowledge is human knowledge; it grows out of human hopes, fears and passions. Imaginative engagement with knowledge come from learning in the context of the hopes, fears, and passions from which it has grown or in which it finds a living meaning. Egan, K. (2008, Dec), Education Matters [TV series]. Burnaby SFU.

3.5 LIST OF DESIGN CONSIDERATIONS

<table>
<thead>
<tr>
<th>Design directly to target demographic</th>
<th>Create content geared directly toward children in the 7-10 year old age category. Based content on an age specific level of understanding and cognitive abilities. Choose content that is appropriate for that age. i.e. bright colours and simple line art.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make interface easy to use</td>
<td>Use tangible stamps to facilitate physical interaction that children prefer.</td>
</tr>
<tr>
<td>Invite exploration, curiosity and play</td>
<td>As a means of enhancing engagement, an exploratory interface was created where children could control their interaction. Encourage play by having children stamp out their own ideas of a sustainable community could be created</td>
</tr>
<tr>
<td>Centre the activity around role-playing</td>
<td>Create engagement through role-playing where children interact with content by pretending to be an Engineer.</td>
</tr>
<tr>
<td>Use voiceovers instead of written words to communicate information.</td>
<td>Use voiceover narration of animated characters Lucky Ducky and the Engineer. To utilize cognitive load theory of multimedia learning.</td>
</tr>
<tr>
<td>Use ambient sound as a mechanism for enhancing sensory &amp; imaginative immersion</td>
<td>Use sound as a way to enhance learning through representational ambient sounds (birds, children laughing, car horns etc.)</td>
</tr>
</tbody>
</table>

Table 1.1 List of Design Considerations Based on Theory
3.6 DESIGN RATIONALE

First, I targeted the content to the demographic of this research (children aged 7-10). I organized the learning content into thirteen categories that encompassed the majority of sustainability ideas I wanted the children to learn (see section on learning instrument, Chapter 4). I researched the appropriate look and feel for the content for this age group. I designed the graphics to be simple and clean so there was no ambiguity to their meaning.

Supported by research into this age group’s learning style, it was decided that it would be too complicated and required too much cognitive load to incorporate all features into one interface. Therefore, functions were separated into two component (gather info and apply info) in order to make the experience with the learning system easier.

3.7 THE RESEARCH INSTRUMENT PHYSICAL SETTING

With a keen interest in supporting children to construct knowledge through play and playful activities, a group called Lifelong Kindergarten from MIT has challenged the current system of education. Michael Resnick (2004), in his paper entitled Edutainment? No I Prefer Playful Learning, makes an argument for entertainment that encourages an environment in which children can learn though playful exploration. “So where should one look to find playful learning? Museums provide some of the best examples – particularly children’s museums and science museums” (p. 3)
Resnick suggests that learning through play is an important and often a missed opportunity in school-based curricula. He recommends museums as the best place to look for playful learning. Following Resnick’s claim, such museums, then, would be good choices for bringing out “playful learning.”

Another pivotal work is that of Haywood and Cairns (2005). In a paper entitled *Engagement with an Interactive Museum Exhibit*, these authors state:

"Museums are a major source of public education outside of the formal schooling system in the UK. However, rather than competing with formal education, they provide a complementary resource for formal and informal learning. For example, many museum visitors are groups of school pupils who visit the museum as part of their formal education. Further, many museum visitors are families, with parents aiming to allow their children to encounter areas of informal education that they may not otherwise encounter. Museums also function as a source of leisure and entertainment. Indeed, museums are one of the central provisions for entertainment, which are widely accessible to the general public. Thus, museums must aim to provide entertainment that is simultaneously informative and educational. Increasingly, museums look to interactive exhibits to fulfill this aim. (p. 3)"

Following the pedagogical views of Resnick (2004) and those of Haywood and Cairns (p. 3), it was decided to select a local science museum or similar setting in which to conduct the study.

### 3.8 ENGAGING THE SEVEN-TO-TEN-YEAR OLD MIND

Kieran Egan is an educational theorist who proposed a new idea in education that supports learning through imagination and engagement.

Egan (1998) describes the mapping of knowledge and espouses the concept that humans fill in their own knowledge bases. There are two leading
theories on the integration of knowledge and scaffolding. The first concept is that of the jigsaw, where ideas are individually explored and then integrated. The second concept involves the holographic approach, in which things appear unclear and are gradually filled in with knowledge acquisition. Each scaffold hypothesis builds on previous knowledge and understanding. Each can be seen as a foundational structure that supports all new knowledge acquisition. My intention was to create a scaffold-as-foundation in order to live in harmony with nature and sustainability, which is an underlying foundation for future understanding of our place in the natural world. This is because, all told, we humans are the ones that need “sustaining.” Nature will continue to exist, with or without human beings.

In his book *The Educated Mind: How Cognitive Tools Shape Our Understanding*, Egan (1998) says the current pedagogy is based on three educational theories:

1. **Plato** – the belief that reason and knowledge drive the development of a student’s mind, specifically toward the education of the “elite” of society.

2. **Rousseau** – whereby the student’s cognitive development drives the educational pursuit.

3. **Third**, the theory that education is the process of socializing a child.

Egan argues these theories taken together are untenable and are to blame for our current “educational crisis.” In Egan’s view, the educational system fails
because it tries to incorporate all three ideas, which are mutually exclusive, and fails to achieve any aims of any theory effectively.

Egan identifies what he considers a more natural way to learn, based on cognitive science and the way the mind understands information. Moving away from accepted notions of educational theory and practice, Egan proposes a radical new way to look at education. He identifies five kinds of understanding that are largely age-based, with each building on the previous level of understanding: (a) somatic - physical understanding; (b) mythic - opposition-based logic, black/white, hot/cold etc., (with the introduction of language understanding comes narrative and stories); (c) romantic - beyond the mythic and into the realms of “romance, wonder and awe,” a time of revolt against convention, where heroes and extremes dominate the learning process; (d) philosophic - looking into the underlying patterns in “romantic understanding” and organizing them into general and coherent schemes; and finally (e) ironic - the mental flexibility to recognize that our understanding of things is inadequate and that we need to explore alternative philosophic explanations with deep reasoning.

For me, the area of specific interest, for the purposes of this research project, is “Romantic Learning,” which Egan claims emerges at approximately eight years of age. He states, “Romantic understanding is lively, energetic, less concerned with systematic structure than with unexpected connections and the delight they can bring.” For Egan, romantic understanding focuses on how the
typical eight-to-fifteen year-old engages with knowledge and makes sense of his or her experience. He claims the focus should be on the humanization of knowledge in a cultural, social and emotional context:

Romantic understanding, then, is a somewhat distinctive kind of understanding supported by an alphabetic literacy bent to the development of rationality. Central to Romantic understanding is a sense of an autonomous self and a relatedly autonomous reality. This is, of course, an imprecise and unsatisfactory way of putting it. Clearly, younger children live and deal with reality and with an autonomous, external world. But, equally clearly, there is commonly a shift in children's understanding of that reality around the period when literacy becomes internalized.... Romantic understanding represents a gradual transition. Students' forms of thinking gradually accommodate to the shapes of autonomous reality, but they first make sense of reality in ‘romantic’ terms.(p. 101)

The important question raised here is how best to reach children based on their learning preference for the ages between 7-10. Egan emphasizes that the goal is to promote philosophic thinking and sophisticated insight. Egan also created a variety of frameworks. Some directed at the “RomanticLearner” (The Imaginative Education Research Group, 2009)

The following information was drawn upon as design considerations for the tangible user interface used in this project.

During the process of designing the research instrument, the concepts contained in Egan’s framework were always kept in mind. The interface incorporated as many features of this framework as possible. The interface was designed in such a way as to attempt to keep the children engaged through playful interaction.
One of the methods by which such a principle was implemented was to structure the interaction with the interface around the concept of it all being a kind of role-playing game. I decided to implement this procedure by having each child who participated assume the persona of someone who makes major policy decisions about creating a sustainable environment. The interface would then automatically “implement” these decisions and display the results. The participants would be able to observe the (simulated) long-term consequences of their decisions and policies. Thus the game would give each participant a sense of what it is like and how it feels to make such decisions and witness the consequences. Such a role playing game would give them exposure to making choices that can potentially create a better (or worse) future, hopefully producing an affective resonance between the children and the content, spark imagination and give them hope for a better future.

Similar to the ideas of Egan are those of D.W. Winnicott, a psychologist who specializes in the role of play. Winnicott says:

“To get to the idea of playing it is helpful to think of the preoccupation that characterizes the playing of a young child. The content does not matter. What matters is the near withdrawal state, akin to concentration... The playing child inhabits an area that cannot be easily left, nor can it easily admit intrusion. (Winnicott, 1971, p. 51)"

In his book, Playing and Reality, Winnicott, (1971) defines stages of childhood. According to him, the stages are: Stage one: The baby perceives no difference between himself and an object. Stage two: The object is repudiated, re-
accepted and perceived objectively as an object separate from self. Stage three: People and action become reflected in play activity, and mimicry is predominant.

Stage four: Play is a means to accept and reject ideas. Winnicott contends that play itself acts as a mechanism for maturation and understanding. In Winnicott’s thinking, play is also symbolic of struggles for identity and context within the outer world. Stage four holds promise for the development of multimedia to support a child’s need for understanding her/his place in the world. If play is the key to engagement, then play would be an essential ingredient to incorporate into any effective TUI designed for educational purposes. Therefore, when designing the interface for this project, following the ideas of Winnicott, it was decided to attempt to make the experience of the participants be as playful as possible.

3.9 SUSPENSION OF DISBELIEF, IMMERSION & ENGAGEMENT

As discussed in the previous chapters, suspension of disbelief allows people to respond to what they know to be fiction as if it were reality, at least to some degree. Suspension of disbelief is a mental process whereby people allow themselves to pretend to believe something that they know is not true, entirely for the sake of active enjoyment and engagement. In the context of this project, the practical question becomes: How can we most effectively apply this principle to the design of a TUI?

Janet Murray speaks directly to the concept of suspension of disbelief in relation to interactivity in her book, Hamlet on the Hollodeck (1997), but she refers
to the process as “the active creation of belief” (p.110), and as discussed in Chapter 2, both of these are concepts are approximately equivalent to what Ermi and Måyrä (2005) refer to as imaginative immersion. The principle of suspension of disbelief is extremely useful for the creation of tangible user interfaces for children, since play-acting is so natural to them, and since they willingly suspend disbelief in order to actively engage with the interfaces. Murray goes on to say, "In digital environments we have new opportunities to practice this active creation of belief." She then describes her group’s design for language learners involving a virtual working phone. The virtual phone became the focal point of the interaction, eclipsing other interactive features. Murray states:

"The telephone was one of the most popular features of the story. This was because it behaved as a functional virtual object and because it became part of the accomplishment of a specific goal. In short it became real through use. (p. 111)

The principle of “real-through-use” is an interesting description of the phenomenon of imaginative immersion and engagement. When people are fully engaged through immersion, the term "real-though-use" amply describes the sensation of acceptance and belonging that full engagement creates. Murray also states, "Our successful engagement with these enticing objects makes for a little feedback loop that urges us on to more engagement, which leads to more belief." (p. 112).

Imaginative immersion contains, therefore, the idea of active engagement with the content, and through active engagement, acceptance is achieved. This in turn leads to richer learning experiences. The principle of active engagement is a
very important principle for the design of interfaces, for it implies the more physically active the participant is in response to features of the interface, rather than merely being a passive receiver of the information, the greater will be the sense of imaginative immersion. Following the general concept of imaginative immersion, as well as Egan’s concepts about the importance of play, one of the methods by which such principles were implemented was to structure the interaction with the interface around the concept of it all being a kind of role playing game. I decided to implement this procedure by having each child who participated assume the persona of someone who makes major policy decisions about creating a sustainable environment. Some type of a tangible interface would therefore need to be created that could respond to the intentions and decisions made by the participants, which would then automatically “implement” these decisions and display the results in a very vivid and meaningful way. The participants would be able to observe the (simulated) long-term consequences of their decisions and policies. Thus the game would give each participant a sense of what it is like and how it feels to make such decisions and witness the consequences. Such a role playing game would give them exposure to making choices that can potentially create a better future (or worse) future, hopefully producing an affective resonance between the children and the content, spark imagination and give them hope for a better future.

Furthermore, based on Murray’s concepts about real-through-use discussed previously, I decided to centre the interface around some kind of
highly interactive feature akin to Murray’s virtual telephone. This needed to be some kind of interactive tool the participants could physically interact with much like Murray’s “boundary object,” manipulating it as part of their making and/or implementing decisions that effected the environment and ecology. This role-playing aspect combined with the interaction tool needed to form the central nucleus of the interface.

3.10 MEASUREMENT OF SUSPENSION OF DISBELIEF, IMMERSION & ENGAGEMENT

Because of the subjective and somewhat ephemeral nature of these phenomena referred to as suspension of disbelief, imaginative immersion, and engagement, a considerable amount of thought was devoted to how a research instrument and an experiment could be designed that would permit such mental states to be operationalized and measured.

Ideally, the instrument and the study would have been designed to directly measure suspension of disbelief, active creation of belief or at least imaginative immersion. Unfortunately, no scientifically valid or plausible direct means of measuring these experiences was found. The only means to measure them are indirect measures. As discussed in chapter 2, according to the formulation of Ermi and Māyrā (2005), both suspension of disbelief and active creation of belief can be considered special cases of what they refer to as imaginative immersion, and engagement can be considered a broader, more inclusive generic category that includes all of the three kinds of immersion. If one
could obtain a measurement of engagement, this could be considered an indirect measure of immersion, including imaginative immersion, and thus, at least to some extent, suspension of disbelief.

As Xie, et al. (2008) point out, several plausible objective measures of engagement have been proposed. For instance, since essentially all attempts to define engagement have included ideas about it involving intense interest, intense cognitive effort, strong concentration of attention to a task, or deep processing of new information (Salomen & Globerson, 1987), various authors have proposed measures of engagement based on observations of time spent on a target task relative to alternative activities (Africano, et al., 2004).

There is a certain commonsense, intuitive appeal to such a formation. Almost by definition, games that people will voluntarily spend hours playing are more engaging than those with which they lose interest after a few minutes. The same could be said of any tasks people eagerly participate in for long periods of time compared to those they tend to want to dispense with quickly or avoid altogether. Therefore, measures of the amount of time a participant spends focused on a task relative to other available options would seem to be a self-evidently valid measure of engagement.

Under certain circumstances, the validity of such a formulation seems impossible to deny. For example, two video presentations or video games can be compared in a situation in which the participants know they have the option to watch or play as briefly or as long as they wish. In such a situation, clearly, an
item which people voluntarily stayed with for several hours, and keep returning to at every opportunity, could be said to be highly engaging. Conversely, an item people lost interest in after a minute or two, and never voluntarily returned to again could be said to be not very engaging. A very objective and quantitative measure could be created around this such as number of minutes per day spent involved in the activity.

However, as Xie, et al. (2008) point out, such an “on task time” measure is not without severe drawbacks in many situations. For instance, the amount of time a person requires to complete a task also probably correlates with variables related to the difficulty of a task. Similarly people can sometimes take forever to complete a dull task because they avoid devoting the requisite time, attention or mental resources to it. This would be more of a problem in some contexts than other, but the nature of the Towards Utopia project seemed to be one in which time spent completing the task would be especially difficult to interpret as a measure of engagement. In what sense could it legitimately be claimed that those who took longer to create their proposed sustainable community were more engaged than those who completed the task in less time?

Xie (2009) also point out another general approach for measuring engagement, which is centered around attempts to measure it in terms of how enjoyable the participants experience the activity as being. The verbal descriptors of immersion/engagement used by various authors and researchers include concepts like extreme interest, attractiveness or fascination, which imply they
assume the activities are very interesting and thus enjoyable. Pimentel and Teixeira's (1993, p. 69) definition of engagement explicitly suggests it be measured in terms of how well “does it capture your interest?” The fact that makers of computer games and similar products are concerned with how to increase the engagement of their products seems to at least tacitly assume they are thinking in terms of a rough equivalence between engagement and fun, even when they do not explicitly say so. Even Csikszentmihalyi’s (1990) description of flow, or Emri and Marya’s (2005) description of challenge-based immersion come very close to being synonyms of colloquial and commonsense notions of fun. Therefore, a measure of people’s enjoyment in a task could be thought of as at least a good indirect measure of people’s engagement in the task.

As Xie, (2009) make clear, although enjoyment correlates well with engagement, engagement and enjoyment are nevertheless quite distinct experiences. Engagement is generally conceived of a being related to attentive, perceptual and cognitive processes, whereas enjoyment seems to refer more to emotional/kinesthetic processes.

Such a correlation is, of course, far from perfect, but is nevertheless very useful. If a person finds an experience dull, boring, stressful, repulsive, irritating or agonizing it would not be reasonable to say they found it engaging. Likewise, if someone experiences an activity or event as extremely pleasant and enjoyable, that almost seems to presuppose they found it engaging. It is possible to imagine counter examples - experiences people may find engaging that are accompanied
by emotions other than enjoyment. A truly good horror movie tends to arouse a measure of fear, not joy, and many of the best love stories evoke sadness. It is also easy to think of experiences like relaxing on a warm sunny beach or taking long luxurious hot bath that are quite enjoyable, but do not seem to possess the feature of intensely focused attention or deep concentration that is almost universally presumed to be a key descriptor of engagement. Therefore, Xie, et al. (2008) do not equate enjoyment with engagement, rather they merely claim that engagement and enjoyment may be closely correlated for some activities.

Because of this close correlation and the nature of the activity (experimental setting) it is probably a much better measure of engagement than what many previous authors such as Africano et al. (2004) have proposed (i.e. task time). Therefore, in practical terms, the measuring of enjoyment may offer an excellent, though indirect, measure of engagement.

Nevertheless, enjoyment is still a subjective phenomenon, so we are still confronted with the question of how to measure it. Xie (2008) points to two general approaches to the matter. The first involves using observations and scorings of non-verbal behavior, such as smiles, laughter, gleeful vocalizations and other outward expressions of what seem to observers to be evidence of enjoyment (Read, MacFarlane & Casey, 2002). Conversely, Hanna, Neapolitan, and Risden (2004), propose the observation of behaviors such as yawns, frowns and negative-sounding vocalizations as reliable indicators of the absence of engagement.
Of course, as Xie, Antle, and Motamedi (2008) note, facial expressions, vocalizations, and other non-verbal cues are potentially very ambiguous and vulnerable to multiple interpretations. Is a particular smile evidence of a person feeling enjoyment, nervousness, or embarrassment? If a person stares motionless at a screen for a lengthy period of time, is this evidence they are fascinated and enjoying themselves, or merely confused, perplexed or bewildered? Do they laugh because they are enjoying themselves, feeling apprehensive or experiencing contempt?

Despite the very real matter of ambiguity, it would nevertheless be possible to conduct a blind (or double blind) study which used non-verbal cues as a measure of enjoyment. Participants could be videotaped while involved in an interaction with an interface. The tapes could later be watched and scored by a number of independent observers who knew nothing about the content of the presentation, the purpose of the study, or which condition each participant was assigned to. The evaluators would simply be asked to examine the non-verbal cues and formulate their own opinions about the degree to which each participant was enjoying activity or not. If conducted with care and precision, and the errors and subjective biases averaged out over a large number of participants and evaluators, such a study should be able to determine with reasonable accuracy the degree of enjoyment evoked by any particular presentation or interaction.
People of all ages tend to have fairly definite and clear opinions about the degree to which they do or do not enjoy a particular experience, and when given the opportunity to express such opinions in an unpressured way, usually do so quite accurately and reliably. Therefore there is a much simpler and more direct measure of enjoyment: self-reports by the participants.

As pointed out by Xie, et al. (2008) an excellent instrument for eliciting self-reports of individual enjoyment already exists. This instrument, created by Ryan (2006), is called the Intrinsic Motivation Indicator Questionnaire (IMI). The questionnaire includes a number of verbal questions related to the individual’s enjoyment of a particular event, presentation or experience. The IMI is readily adaptable to almost any kind of setting, activity or event, and is particularly well suited to measuring responses to multimedia presentations or programs.

Each item on the IMI is scored on a Likert scale. This can be done using an ordinary seven-point Likert scale used with adults, or used with a special modified Likert scale specifically adapted for use by children (Read et al., 2002).

This method for measuring the level of engagement indirectly by measuring enjoyment with such a modified Likert scale has three distinct advantages:

1. It may correlate well with engagement, both in terms of intuitive notions of engagement, as well as with the verbal descriptors of such states used by the experts in the field when they write about engagement.
2. The existing IMI, which is very easy to administer, and has already been tested for validity and reliability by recognized expert ludologists in previously published works (Ryan, 2006).

3. The IMI, combined with the child-friendly Likert scale, would provide a very straightforward and quantitative measure of enjoyment/engagement, not a vague or difficult to interpret qualitative measure. Therefore, taking all of this into consideration, it was decided to use enjoyment as an indirect measure of engagement, to measure enjoyment using the IMI designed by Ryan (2006) and the Likert scale that had been specifically designed for use by children (Read, et al. 2002).

3.11 DESIGNING AMBIENT SOUND TO SUPPORT ENGAGEMENT

The central question addressed in this study was whether ambient sound is one of the mechanisms that can promote engagement, which in turn leads to improved children’s learning. In TUIs, the designer creates a learning environment though visual, audio and kinesthetic information. The augmentation of reality creates a level of connectedness in the user with the digital content, and leads him or her to more active engagement and to imaginative immersion. How can designers use ambient sound to create a richer learning experience through enhanced engagement?

Chion (1994, p. 75) describes ambient sound as being “sound that envelops a scene and inhabits its space, without raising the question of the identification or visual embodiment of its source.” Ambient sound provides
continuity within scenes. With regard to interactivity, it also helps to “suture” together disparate interactive elements to create a cohesive whole. It can potentially lead a participant to deeper connection with the content, and, if well done, it can create imaginative immersion and engagement. Ambient sound can set the tone and mood of the interaction, creating in an individual an affective response to the environment.

As mentioned in Chapter 2, Chion (1994) regards sound as an essential element in creating a “space” around the images. Chion also discusses what he refers to as a metaphorical distance, which he says creates dimensionality. The fusion of image and sound, he says, creates this “dimensionality” as separate parts of our brain process the sensory information.

"Fusing image and sound in a film produces “dimensionality” that the mind projects back onto the image as if had come from the image in the first place. (p. 21)"

This extra dimensionality theoretically will allow for a deeper level of comprehension and synthesis of information, a new patterning within the brain.

Chion addresses the concept of the auditory scene. He describes sounds as being on screen, off screen and non-diegetic. Chion calls ambient sound “territory-sound” - sound that identifies a locale through its continual presence. It is considered off-scene largely because it is not part of narration. But territory-sound is never entirely off-scene since it makes its presence known. For Chion, ambient sound appears to have a secondary importance relative to diegesis (narration). This seems largely due to cognitive processes whereby the human
brain is specifically structured to focus on: vocals = narrative/linguistic + visuals = image/movement:

"The most widespread function of film sound consists of unifying or binding the flow of images. First, in temporal terms, it unifies by bridging the visual breaks though sound overlaps. Second, it brings unity by establishing atmosphere (e.g., birdsongs or traffic sounds) as a framework that seems to contain the image, a 'heard space' in which the 'seen' bathes. And third, sound can provide unity through nondiegetic music because this music is independent of the notion of real time and space it can cast the images into a homogenizing bath or current. (Chion, 1994, p. 47-48)

In his book, *Theory of Film Practice*, Noël Burch (1973) discussed the use of sound in cinema. He termed sound as either “live” or “dubbed,” “off screen” or “on screen,” and referenced the apparent microphone distance as either “close” or “far away.” He described the volume and its ambient context - in a hallway, outdoors, over a telephone line - and the interaction of several sounds at once as “overlap” (p. 313). Burch also referenced Bazin’s concept of “depth of field” from the book *Language of Cinema* as related to the film soundtrack. “Foreground we hear the dialogue, in the background or off screen we hear other sounds, music for example” (p. 313).

According to Bordwell and Thompson (2004) in their *Film Art and Introduction*, there are fundamental properties to film sound. They are the perceptual properties of sound and are familiar to us from everyday interaction. They include these three components:
1. **Loudness (volume)** - Film sound constantly manipulates the volume to accommodate dialog. Volume also relates to perceived distance - the louder the sound, the closer to us. Bordwell and Thompson’s examples include dialog as being in the acoustic foreground. In contrast, sounds like traffic are categorized as being in the acoustic background (p. 350).

2. **Pitch** - The perceived highness or lowness of sound based on frequency. Pitch helps the audience distinguish between dialog and other sounds such as music and pure noise (p. 351).

3. **Timbre** - The harmonic component that gives “colour and tone” to music. It is the feel of the song.

From Bordwell and Thompson’s perspective, loudness, pitch and timbre interact to create the “sonic texture” of a film and shape the film’s experience as a whole (p. 351). They also describe “dramatic sound” as the choice and combination of sounds that create patterns throughout a film. Rhythm, melody and harmony combine to create an affective emotional connection for the viewers.

Altman (1992) describes a similar concept in his book *Sound Theory / Sound Practice*. He refers to this concept as “soundscape.” Altman describes soundscape as the characteristic type of sound commonly heard in a given period and/or
location. For instance, Altman would say the soundscape of pre-industrial England was totally different from the soundscape of the same location today. This is because the configuration of sounds people hear there now - automobile traffic, airplanes, machinery, electronically enhanced music, etc., is entirely different than the total collection of sounds created by horses, birds, agricultural activities and live music of 200 years ago. “In much of our world, today’s soundscape is characterized by competition among multiple amplified sounds, along with attempts (like the walkman and acoustic panels) to restore individual aural autonomy in sound micro-atmosphere.”

It was decided to implement these concepts in the Towards Utopia learning system by attempting to thoroughly replicate the soundscape of modern day Vancouver, for better or worse, in its delivery of ambient sounds.

Chiron also refers to another theory called “synchresis,” the combination of the words synchronization and synthesis: “That is to say a sound once free of the object can reattach itself to a wider range of other objects (images).” In this way of thinking, there is a mental fusion within the audience member between concurrent sound and visuals: the perceptual recombining of sound as synchronization. According to Chion, “A point of synchronization, or synch point, is a salient moment of an audiovisual sequence during which a sound event and visual event meet in synchrony.”

“Synchresis (a word I have forged by combining synchronism and synthesis) is the spontaneous and irresistible weld produced between a particular auditory phenomenon and visual phenomenon when they occur at the same time. This join results independently of any rational
logic. Synchresis is responsible for our conviction that the sounds heard over the shots of the hands in the prologue of Persona are indeed the sounds of the hammer pounding nails into them. (Chion, 1994, p. 47-48)

These principles seem related to the notion of sensory immersion and apodicticity, as discussed in Chapter 2. Chiron’s claim here is that sound is part of the function of meaning. The merging of sound and image creates a form of sychresis that brings understanding to a deeper level.

Chiron also loosely ties this to the concept of a gestalt. It is the mind’s logic that organizes and assigns extra meaning to the sound, and through a principle of gestalt gives cohesion.

### 3.12 SOUND FORMAT

There were considerations in favour and against attempting to create the ambient sound effects using a more elaborate audio system, such as some type of binaural audio system, or a many-channelled surround sound type of format. Using such a system potentially offered the attractive advantage of achieving greater realism, and therefore perhaps an enhancement of sensory immersion.

However, there were several disadvantages to selecting these options. For binaural audio, one significant drawback was that it is difficult to recreate high quality binaural sound effects for a listener without the use of headphones. Playback through an ordinary stereo system, which normally employs a pair of two speakers placed to the left and right side of the listener, tends to greatly dilute the effectiveness of binaural audio. This is especially the case in an environment subject to significant noise bleed, which was known to be problematic in the
designated experimental space. Secondly, the requirement that the participants wear headphones was felt to be a possible impediment to the free movement of the subjects using a TUI within the experimental space, which was something considered undesirable.

Furthermore, the sound files of the specific type and content were readily available in ordinary high quality stereo, but no such library of suitable sounds in a binaural format was known to exist. Though it would have been technically possible to custom design and create the required set of audio files in a binaural or other three-dimensional format, time constraints and budgetary considerations made this option undesirable from a practical perspective.

Various audio formats involving additional audio channels requiring six or more speakers was also considered. These probably would have also greatly increased the potential for sensory immersion, but there were limitations in terms of the bulk and weight of equipment that could readily be transported to and set-up within the experimental space, which served to deter the use of any extra speakers, amplifiers or other electronic equipment that would not be absolutely necessary.

Because of these considerations, it was decided that high-quality, dual channel stereo files and play back through a set of two speakers would used in the experiment.
3.13 VOICEOVERS IN AN EDUCATIONAL CONTEXT

Computer technology today allows for rich learning experiences to be explored. With the proliferation of technology and the low cost of memory, we have an environment in which integrating audio is feasible for most applications. Voice is powerful and expressive and may serve as an aid to improve engagement and motivation. Having a virtual agent (cartoon character) is useful way to draw children into the content and also has the potential to create empathy as well. Audio instruction with virtual agents is useful for children that are yet to be readers and can aid in learning outcomes in an educational context. The main goal when using voiceovers is clarity with good enunciation and pace suitable to the audience while highlighting key concepts and ideas. Nothing should be redundant and only information that is necessary should be presented in sound bites that are appropriate for the age and ability of the target audience.

Consistent with the findings of Mayer (2001), it was decided to supply the linguistic information for the interface via voiceover narration rather than through visual information. This was done because children aged 7-10 still have only rudimentary reading skills and benefit from audio based instruction (Calandra, Barron, Thompson-Sellers). Had the target demographic been older, another format might have been chosen to emphasize the ambient sound aspect of the experiment, but this format seemed best suited from an instructional design standpoint.
3.14 COSTUMES & ROLE PLAY

...using theatrical methods of make believe and dressing up as an emotional framework for the workshop has proven a useful way to scaffold the experience and aid the suspension of disbelief. The children show high levels of concentration and enthusiasm and the workshops have produced useful data..."(Anderson, 2004, p. 1242)

For the purpose of making the interactive experience more comfortable for children, with imaginative immersion as a mechanism for enhancing engagement, it was decided to incorporate the use of costumes to deepen play with the TUI. The costume was designed to reinforce the imaginary role the participants were assigned to play during the study.

3.15 TOWARDS UTOPIA

Utopia can be thought of as the perfect place, especially with regards to social, political, moral goals and ideologies. It is an ideal state, where the environment is in balance with the needs of human kind. The models for understanding “Utopia” in literature go back to Plato’s Republic and his references to Atlantis in his Critias and Timaeus. Atlantis was a mystical island, populated with an advanced and moral citizenry, that somehow, unfortunately, sank into the sea. Atlantis symbolizes a longing for an ideal culture that was lost.

Plato’s Atlantis may have been an imaginary attempt to showcase a society perfect in every way, the perfectly run state. The fact that such a perfect world never has existed in reality, and never will exist in reality, does not diminish the appeal and attractiveness of such imagery and ideals to the human imagination. The human race may never achieve a perfect society, but there is
always room for improvement. The dream of Atlantis, reborn any time we see society change, is the harbinger of what something deep insider us tells us could be. The dream contains our hopes for a better future. Utopia may always be unattainable, but submerged meters below the surface of our cosmic blue sphere is our hope for a better world. This blue sphere is our only home, and we need it for our existence. Our World, our Utopia, our Earth.

3.16 SOCIAL MOTIVATION

Let us here briefly introduce some of the main issues related to this problem. This includes the nature of the political stagnation, the potential of education to counteract this stagnation, the special power of multimedia education in this regard, and the value of ambient sound as a means to enhance the effectiveness of multimedia education.

"...history slows down as it brushes up against the astral body of the 'silent majorities. Our societies are governed by this process of the mass, and not only in the sociological or demographical sense of the word, but also in the sense of a 'critical mass,' of going beyond a certain point of no-return. That is where the crucially significant event of these societies is to be found: the advent of their revolutionary process along the lines of their mobility (they are all revolutionary with respect to the centuries gone by), of their equivalent force of inertia, of an immense indifference, and of the silent power of this indifference. This inert matter of the social is not due to a lack of exchanges, of information or of communication; on the contrary, it is the result of the multiplication and saturation of exchanges. It is borne of the hyperdensity of cities, of merchandise, messages and circuits. It is the cold star of the social, a mass at the peripheries of which history cools out. Successive events attain their annihilation in indifference."
From the perspective of Baudrillard (1992), it is this “indifference” that is the inertia which works against implementation of much-needed changes with respect to sustainability issues. For Baudrillard, the older generation of citizens might not have the political will to make the necessary changes. But hopefully, if the younger generation is well-educated about issues related to sustainability, our future politicians and voters will develop the will to change (Fuller, 1981; Meadows, Meadows & Randers, 1972, 1992). Focusing our attention on the young might allow us passage through the storm. Children are our future, but I believe it is the responsibility of all of us to think about the world we leave behind. I believe society needs to act to create the “critical mass” of change... and therein lies hope.

"Humanity too, had its big-bang: a certain critical density, a certain concentration of people and exchanges that compel this explosion we call history and which is none other than the dispersal of dense and hieratic cores of earlier civilizations. Today, we are living an effect of reversal: we have overstepped the threshold of critical mass with respect to populations, events, information, control of the inverse process of inertia of history and politics. At the cosmic level of things, we don't know anymore whether we have reached this speed of liberation wherein we would be partaking of a permanent or final expansion. (Baudrillard, 1992, p. 4)"
The media often portrays our moment in time as being at the precipice. When we study the headlines, it is hard to avoid feeling that the human species is heading straight off a cliff. For example, the following is taken directly from the Live Smart BC website (2009):

"Many parts of B.C. have been warming at a rate that is twice the global average. It isn't hard to see the impact that climate change has already had on our province: the mountain pine beetle epidemic, the storms that devastated Stanley Park, the floods of 2007, the loss of water supply to over 900,000 people in 2006, the wildfires of 2003 and the depletion of our glaciers. These effects of global warming have already taken a heavy toll on our economy, our natural resources and people's homes and livelihoods. It's clear that it's hurting our province. It's time for all of us to take action."

3.17 EDUCATION AS A MEANS TO COUNTERACT INDIFFERENCE

The challenge is daunting, but most authors who have examined the subject, such as Meadows et al. (1992) believe it is still probably possible changes can be made which will slow environmental degradation down to manageable levels. I believe change in behaviour must begin with all of us, but I also believe that children will give us the best hope of lasting behavioural changes. While it is difficult to predict the course of future events with any degree of confidence, various authors, including Buckminster Fuller (1981) and Meadows et al. (1992) have claimed that the longer humanity as a species waits to respond to environmental destruction, the longer it will probably take future generations to
repair the damage and restore a semblance of ecological stability to the global environment. I therefore believe it is of the utmost importance to engage our children now to work with us to create a more sustainable future. I believe it is important to instill in children values that prize sustainable behaviour and lay the foundation for a sustainable future.

I believe that future generations of environmentally responsible children are necessary to make the core changes in future communities and economies. Some of our future leaders are learning about the world right now. It seems to me the responsible course of action would be to raise them as sustainable citizens who wisely use the energy, water, land, and other resources that make up our planet. If this is to be the goal, then I believe the education surrounding sustainability needs to emphasize the connections among ourselves, other people, other species, and our planet Earth.

Can technology offer the opportunity for us to recreate Utopia? Can we, through the vehicle of technology, find a way to attain a new Utopia, where we live in balance with nature?

This is why I decided to name the research instrument for the project Towards Utopia.

### 3.18 Design Objectives Summary

With all of these ideas in mind, the interface for Towards Utopia was designed with careful consideration of the target age group, and in consultation with an expert in the field of child education. It was hoped that by interacting
with a TUI interface, children could naturally interact with the technology in a way that increased immersion with the content. TUIs add marvel and bring grace and elegance into form in an engaging, unexpected, and novel way. The interface thus created was then used as a vehicle to assess whether or not ambient sound actually enhances the educational process.

3.19 DESCRIPTION OF THE TANGIBLE LEARNING SYSTEM

Here is a brief description of the three main components of the *Towards Utopia* Tangible Learning System. For more detail, see the methodology section regarding the learning instrument.

3.19.1 STAMPS (USED FOR BOTH TABLETOP & RFID STATION)

The programmer Karen Tanenbaum and I created the thirteen physical stamps that were equipped with fiducial markers and RFID tags. Each stamp had an easy identification tag so the children could tell by picking up the stamp what the stamp represented. This was to provide optimal haptic sensory information and to take full advantage of the tactile nature of tangible user interfaces.

3.19.2 RFID STATION

The children used an identifier screen (RFID station) that would tell them the function of the stamp. With the RFID station, I wanted them to concentrate on learning the sustainability concepts.
Two cartoon characters were chosen to help present the learning content. The cartoon characters, through voiceover narration, communicated the ideas to the children. The human figure of the engineer was used for any learning content that had human implications or direct human activity. Lucky Ducky was used to present any ideas that were natural and environmentally friendly.

3.19.3 EVENTTABLE TABLETOP

For the tangible tabletop, a map was created of the Coquitlam river, and this map formed the basis for the tabletop interface. This map was chosen since the area was one of the few underdeveloped areas in the Lower Mainland. This made it easy to use without too much retouching. The map chosen is also part of the flood delta that will possibly experience flooding in the future. The image used was the same image that was represented on the RFID screen and the tabletop. The EventTable was used to stamp out their idea of a sustainable community. This was done by using the physical stamps (and potentially listening to the ambient sound in ambient:on condition).
3.20 LIST OF DESIGN CONSIDERATIONS

The main ideas that influenced my design process are listed here:

- Ambient sound leads to a deeper connection with the content/helps imaginative immersion and engagement (Chion 1994).
- Ease of navigation (Buchanan, 2000).
- Create a humane interface responsive to human needs and considerate of human frailties. Always be kind to your user and mindful of their cognitive processes. (Raskin, 2002).
- Invite exploration and curiosity (Buchanan, 2000).
- Design the instrument specifically for children in the seven-to-ten year-old age group. (Paiget, 1930, 1958; Miller, 2004; Mckenzie-Mohr, 1999).
- Use a science museum or similar setting as the site of the experiment (Resnick, 2004; Haywood and Cairns, 2005).
- Design the research instrument to be a mixed reality interface (Rogers, et al., 2004; Jones, et al., 2005) that maximizes opportunities for tactile learning and physical interaction between the participants and the TUI.
- Appeal to the “Romantic Learning” of the participants while encouraging “Philosophical Thought.” (Egan, 1998).
- Design the system to be centred around a real-through-use principle. (Murray, 1997).
- Centre the activity of the participants around a role-playing activity (Murray, 1997; Anderson, 2004).
- Use audio (voiceover) instead of written words to communicate the instructions and verbal information to the participants. (Mayer, 2001; Beeceue, Vila, Whitley, 2001).
- Incorporate play in the structure of the TUI as a means of enhancing engagement (Winnicott, 1971).
CHAPTER 4: METHODOLOGY

The methodological framework for this study was drawn from Research Design: Qualitative, Quantitative and Mixed Methods Approaches (Creswell, 2003), specifically the sections on mixed methodology. This project is an experimental mixed methods approach utilizing a tangible learning system as a research instrument. A mixed methodology approach was decided upon in order to adequately answer the research question which covers the complex interplay of ambient sound, engagement and learning that occurs during a role playing activity about sustainability implemented with a tangible user interface.

4.1 INTRODUCTION TO THE METHODOLOGY

The present research was both quantitatively and qualitatively based. The approach was pragmatic in nature, borrowing from the Constructivist tradition (interviews). A second component used the Post-Positivist tradition of empirical inquiry (pre and post testing). The data was subjective and the research confirmatory with a hypothesis tested.

Described briefly, the experiment involved a TUI prototype, which was intended to enable children to learn about basic concepts related to sustainability. The prototype incorporated the design considerations and principles discussed in Chapter 3. The research study utilized a between subjects
experimental design in which each child used either an ambient sound mode or a non-ambient sound mode of the research instrument, *Towards Utopia*.

### 4.1.1 PARTICIPANTS

The experiment was conducted with 30 children aged seven to ten, who were randomly selected from among the visitors to *Science World*, a science-oriented museum located in Vancouver, British Columbia. The participants were gender balanced (half male, half female). Fifteen participants were evaluated with the ambient sound mode turned on, and fifteen with the ambient sound turned off.

### 4.1.2 STUDY DESIGN

The research question was, *Does ambient sound promote increased engagement in learning?*

The independent variable was ambient sound (on or off). There were three dependent variables: (a) learning outcome; (b) enjoyment; and (c) perceived competence. Enjoyment and perceived competence were used to operationalize engagement in the learning activity.

Learning outcomes refers to the change in each participants’ level of understanding of sustainability concepts, measured in terms of the difference in scores between the pre and post intervention interview style assessment of children’s understanding of sustainability concepts. Enjoyment was measured as a child’s self-report of how enjoyable they perceived the experience to be. It was
measured only once, at the end of the experiment, using a post intervention questionnaire consisting of seven questions taken from the IMI inventory.

Perceived competence was measured as a child’s self-report of how competent they felt during the activity. It was measured once at the end of the experiment, using five more questions taken from the IMI inventory in the post intervention questionnaire.

4.1.3 APPARATUS: RESEARCH INSTRUMENT

The *Towards Utopia* TUI learning system was design specifically for the purposes of this study. To the extent possible, this interface incorporated the design principles and considerations described in chapter 3. This TUI was the central research instrument in this study. A detailed description of this research instrument and its operation is presented in this section.

4.1.4 EXPERIMENTAL SPACE

The *Towards Utopia* experiment was conducted at *Science World*, a non-profit science museum located in Vancouver, British Columbia, on March 28, 29 and April 11, 2009 (Figure 1.1).
The space within which the interface was located and within which the experiment took place played a significant role in the project. This space had various consequences and influences on the project, so the features of this setting are briefly described here.

The location facilitated active recruitment of children in the target age group. This site also provided a large space to work within, both for the set-up and the conducting of the experiment. The allocated space was within the area designated as the Eureka Lab. The approximate size of the space was 20 X 30 feet. This space contained all the components and of the Toward Utopia research.
instrument, including the tangible table, RFID table, video camera, waiting area, snack area and interview area. (Each component, its purpose and function will be explained below). The physical layout of the space allowed for control of lighting.

The space itself was not ideal from the standpoint of lack of sound control, which prevented complete sound containment. There was sound bleed from the other exhibits within *Science World*. At least to some degree, this noise created distraction and interfered with the ability to use ambient sound to create sensory and imaginative immersion. The noise also made it somewhat more difficult to interview the participants. It was necessary to lower the door (similar to a large residential garage door) between the experimental space and the other areas of the facility in order to minimize external noise from intruding into the experimental space. This caused some of the participants to be more apprehensive about the experiment than they otherwise might have been, but this did not seem to present a major problem. The general configuration of the experimental space is shown in Figure 1.2.
The set-up allowed children to flow through the experiment.

The video camera could capture everything that the children did.

Children appreciated the snack table while they waited for their turn at the interface.

Gray lines indicate the typical paths children took during the prototype testing sessions.

After the parents signed the consent form, the children were brought over to the interview table.

Figure 1.2 Spatial Layout at Eureka Lab (Science World)
The *Towards Utopia* learning system consisted of several distinct but interconnected components (summarized in 3.19), each of which will be discussed and explained in turn. These included the EventTable camera-based digital tabletop system and a RFID reader and computer monitor. The EventTable system also includes the reacTiVision system, custom hardware and software as described below.

At the core of the *Towards Utopia* system is a recently-developed interface technology known as the reacTiVision system. The reacTiVision system is a proprietary software system created by Bencina and Kaltenbrunner (2007) for tracking specially designed markers and associated movable objects in a real-time video stream. ReacTiVision was originally designed to enable expressive gestural control of musical sounds within a TUI, but can track up to 74 separate movable objects of any kind at a relatively high frame rate. For this application, amoeba markers as shown in Figure 1.3 were used because they can easily be attached to objects and result in fast accurate tracking. The ReacTiVision software was used to recognize amoeba fiducial markers attached to "stamps" (see Fig 1.3) and to send information about each marker’s identity and location to the EventTable software, which was custom built for this application.
The second major component of the EventTable (Antle, et al., 2009) system was the EventTable itself. The EventTable is a hardware and software implementation of a tabletop tangible user interface prototyping platform. The system uses reactTVision to identify fiducial markers which are typically attached to the underside of a set of movable objects. The objects are then placed upon the upper surface of a translucent table which serves as both an input space and a visual display. A camera located beneath the table captures the images of these markers, which are then processed by the reactTVision software to determine the location, orientation and identity of each fiducial in real time. This information is then sent to the other custom Towards Utopia software component of EventTable.
The EventTable system is highly responsive to the movement, position and orientation of each of the various movable objects, responding by reconfiguring the visual content of the screen and initiating actions in response to their movements. The participants can thus move the objects anywhere on or above the table top, and the system state and corresponding display parameters will be updated appropriately (Figure 1.4).

Figure 1.4 EventTable Tangible System

For the Towards Utopia project, the reactIVsion and EventTable systems were used to create an interactive map in which participants were able to use
various "stamps" to configure a hypothetical landscape by assigning various uses and activities to specific locations. The fiducials were attached to the physical stamps, and interacted with the *Toward Utopia* Tangible Table top, which displayed a topographic map of the Lower Mainland of coastal British Columbia. (Figure 1.5)

The system was specifically designed so that the participants could use the stamps (with fiducials) to “stamp out” their concept for a sustainable community. This activity involved using the stamps to create a simulated landscape by allocating various types of land use in specified amounts to various
precise locations on the computerized map. This simulated community was displayed on an interactive topographic map of the Lower Mainland, with the Fraser River flowing through the middle.

The design of the system allowed participants to continue to add stamps to the simulated landscape in any pattern or sequence they wished until they decided their effort to create a sustainable community was complete. This task was estimated to require approximately 5 to 10 minutes for a typical subject.

Each stamp, through the programming language of processing, would hold a value based on environmental impact: Renewable Energy (+4), Trees/Wetlands (+3), Nature Reserve, Community Gardens & farms (+2), Apartment/Condos (+1), Townhouse (0), Roads/Cars (-1), Single Family Homes (-2), Retail (-3), Industry & Non-renewable energy (-4). The greater the environmental impact, the lower the numeric value. The system was designed to collect all the input about the selection and placement of the various stamps, calculate the probable results of the simulated community created by the pattern of the choices of the user, and then display the results of their future environment on the screen. The outcome presented on the screen would be based on the calculated total impact of stamped images on the landscape in terms of the degree of flooding such a community would be likely to experience.

When the collective impact of a given configuration of stamps was added together by the system, if the total was less than 0, the projected result was a landscape subject to massive flooding. If the result was between 0-10, then the
result was a landscape subject to a lesser (but still significant) amount of flooding. If the net result was greater than 10, this resulted in a simulated landscape which was not subject to flooding. The regions of the map likely to be destroyed by flooding were depicted in a light blue colour distinct from the surrounding territory (Figure 1.6, Figure 1.7 and Figure 1.8).
Figure 1.6 No Flooding

Figure 1.7 Some Flooding

Figure 1.8 Massive Flooding
The nature of the programming of the system, which was intended to accurately simulate the realistic outcome of continued development of the area, caused the majority of the simulated attempts to create sustainable communities to be subject to at least a significant amount of localized flooding of the Lower Mainland. The maps were an artistic representation of the information, collected from the Fraser Basin Council regarding flood data research. (Flood Hazard Management, 2008)
4.1.6 RFID Reader & Computer Monitor

The second part of the Towards Utopia tangible system was a RFID interface, which consisted of a RFID reader, RFID tagged stamps, a monitor, speakers and processing software running on a PC (Fig. 1.9). The system was designed to allow users to gather knowledge about the function and purpose of each stamp by bringing the stamp close to the reader. When brought within a few inches of the reader, an image would appear on the screen revealing what the stamp represented. These were the same 13 stamps described above: Trees/Nature, Nature Reserve, Wetlands/Marshes, Industry, Community
Gardens, Farms, Renewable Energy, Non-Renewable Energy, Single Family Home, Townhouse, Apartment/Condominium, Roads and Retail Business. Each stamp would activate a unique screen with a narrative voiceover description, supporting text, abstract graphical representation (icon) and a realistic photograph representing the stamp’s concepts. (See Appendix A for voiceover and screen-text transcripts). When the system was operating in ambient sound mode, the appropriate ambient sound would also be activated and played at this time. The same stamps were used at the RFID reader and at the tangible tabletop, and ambient sound was used at both of these stations under the ambient sound condition.

### 4.1.7 Implementation of Ambient Sound

The *Towards Utopia* learning system was designed to operate in either of two modes: with ambient sounds mode on, or ambient sound mode off. All of the ambient sounds used were drawn from a pre-existing, pre-defined library of sounds from the *Sound Ideas Sound Effects Library*. Each sound was associated with one of the 13 specific stamps, and intended to be an obvious representation of the land use assigned to its stamp. The sounds associated with each stamp were:


3. Wetlands/Marsh – Sounds of water birds (loons), water gently lapping on shore.

4. Industry – Heavy machinery of a sawmill.


6. Farms – Sounds of farm animals.


10. Townhouse – Sounds of light traffic, birds chirping and people talking.

11. Apartment/Condominium – Sounds of light traffic, people talking and a street light saying “don’t walk,” “don’t walk.”

12. Roads – Sound of medium traffic, some congestion and horns.


Each sound was carefully chosen based on the likelihood it would be representational of the south western British Columbia region, and therefore be familiar to the children who would serve as participants in the study. The
volume of each of the sounds was adjusted so they would all be relatively equivalent in density when overlapped. The sounds would additively overlap at different rates based on number and pattern of the stamps chosen to populate the map.

4.1.8 NARRATIVE (VOICEOVERS)

During the planning phase, in consultation with the educational specialist, it was decided that children of the age of those who would be acting as participants required voiceover narration to guide them through their experience with the *Towards Utopia* learning system. Literacy skills are still under development in many of these children, so it might have proven too challenging for some of them to read the information directly off the screen. Requiring them to do so might have negatively impacted learning potential. This decision was also influenced by material discussed in the literature review - specifically by the multimedia principle of learning, and even more specifically by the theories of dual channel processing (Mayer, 2005).

The voiceovers were recorded by the researcher, with consideration for clarity of dialog and appropriateness of voice. Two character voices were used: Lucky Ducky and The Engineer. The duck was made to speak in a higher frequency voice with distortion deliberately added to make him sound like a cartoon duck. The engineer spoke in a lower frequency voice. Both voices were male. Animated cartoon images of both characters appeared on the screen of the computer at appropriate points in the program. The voiceover sounds were
embedded in the Quick-time movies and matched to the animation cells through character lip synching. The voiceover narration served to guide the participants through the program. The voiceover narration script is located in Appendix A.

4.2 PROCEDURE

4.2.1 SCENARIO FOR USE

The participants were given an orientation to the interface. This is where the participants were introduced to the tangible stamps and shown the two different components of the tangible learning system. They were first shown first to the RFID reader. Once at the station, the computer monitor was activated. Lucky Ducky and the Engineer then introduced them to the concept of creating a sustainable community.

They were then directed to notice the tangible table. At this point, they were told, “This tabletop is a map of Coquitlam, and your goal is to create an environment that is sustainable. After you have finished with learning about what the stamps, do please feel free to move over to the other table.” They are then told, “These stamps allow you to design your environment. In order to find out what they do you will need to identify what each stamp represents. You can do this by placing the stamp on this box. (Hand gestures then indicated the box on the RFID table). At any time during you play if you don’t remember what the stamp will do you may come back to this table.”
The researchers then just watched as the children built their own sustainable community. When the children felt they were done, we revealed the flooding results.

The only difference between the ambient sound:on and the ambient sound:off groups was that ambient sounds were turned on for the ambient sound:on group. Otherwise the experimental conditions were identical.

4.2.2 IMPLEMENTATION

The implementation of the procedure required a team of four people. This team consisted of: (a) an educational specialist (who interviewed the participants and administered the questionnaires); (b) the technical-programmer (who programmed the interface and operated the equipment during the experiment; (c) recruiter (an adolescent male who made the children feel at ease and was able to draw them away from other attractive activities at Science World; and (d) the project lead and official recorder.

After each participant was recruited, the educational specialist interviewed them individually for approximately ten minutes. She informed each participant the people in charge of the project wanted to know what the participant knew about sustainability, and that there were no wrong answers to any of her questions. A script was followed to ensure consistency and to comply with research ethics requirements. The education specialist administered the pre-test interview verbally to evaluate children’s base level of understanding of
sustainability issues. The participants were asked verbal questions and gave
verbal answers. The answers were recorded and transcribed later.

After completion of the pre-test interview, all participants were told they
would be asked additional questions after they had completed their session with
the interface. After the preliminary entrance interview and the pre-test interview
had been administered, participants were invited to play with the Towards Utopia
research instrument.

Participants were randomly assigned to either the ambient sound mode
group or the non-ambient sound mode group. In order to minimize research
bias, the primary researcher did not know which participants had been placed in
the ambient sound group and which were in the non-ambient sound group.

As the first step in their engagement with the research instrument, each
participant was asked to assume the persona of a “sustainability engineer” while
having his or her turn at creating a sustainable environment. Each participant
was given a brief and standardized explanation of what was meant by the term
sustainability engineer, and what they were expected to do in terms of designing
a community that would be sustainable.

Each participant was offered the opportunity to wear the costume
specifically designed for the research project. The costume was a white lab coat
and engineers hat. (The wearing of the costume was gently encouraged but not
required).
The participants were given instructions about what to do, were shown how the interface worked, and were asked to use the system to design a sustainable community that would not be subjected to flooding. The participants then proceeded to use the tangible learning system to create their own version of a sustainable community. Once the participant began the session, the animated characters, Lucky Duck and the Engineer, appeared on the screen, and told the participant about the concepts of sustainability.

The instructions given to the participants encouraged them to actively explore the RFID stamps by placing them on the reader. Each participant was given as much time as needed and allowed to continue until they felt they were finished. (In practice, none of the participants required more than 12 minutes to complete the process).

When the participant had finished creating their community, the system revealed to them whether their community was sustainable or not. This was done by allowing the participants to observe the simulated projected flooding results on the screen, and explaining the significance of what was displayed on the screen.

4.2.3 DATA COLLECTION INSTRUMENTS

There were three dependent variables in this experiment. Two separate instruments were used to collect data.
DV1: Learning Outcome. The first dependent variable was learning outcome, the amount of difference between the participants’ knowledge of sustainability as a result of their experience with the Towards Utopia learning system. This was measured with the first instrument. The questions tested the participants’ knowledge of sustainability and were based on a visual image that was shown to each participant. For each question, the participant was shown an image and asked, “Tell me what you know about this?” After they give their initial response, the participant was then asked, “Anything else?”

These questions were considered open-ended and solicited answers to questions related to the 13 images:

1 - Tree/Nature (a picture of a tree).  
2 - Nature Reserve (a picture of a forest).  
3 - Wetlands/Marsh (a picture of water with bull rushes and grass).  
4 - Industry (a picture of a factory).  
5 - Community Gardens (was a picture of a community garden).  
6 - Farms (a picture of a farm with hay and a barn).  
7 - Renewable energy (a picture of windmills).  
8 - Non-renewable energy (a picture of a conventional power generating station).  
9 - Single family detached home (a picture of a house with car in the driveway).  
10 - Townhouse (a picture of a townhouse with three entrances and a car).  
11 - Apartment/condominium (a picture of two tall high-rise buildings).  
12 - Roads (a picture of heavy congested traffic).  
13 - Retail Business (a picture of a strip mall).

The same set of images and questions was used for both the pre-test and post-test interviews. Participants answered test questions verbally. The answers to the questions were recorded on audiotape to be transcribed later. (Transcripts are located in Appendix C).
Each of the questions had a potential of five points, as scored from zero to five. These responses were scored against a rubric (see Appendix D) in order to convert the subjective, qualitative data into quantitative scores which could be used to assess participant’s change in knowledge of sustainability concepts after using the *Towards Utopia* learning activity. The post-test interview consisted of asking the same set of 13 questions that had been asked at the pre-test interview, and these questions were asked about the same images that had been used in the pre-test.

As in the pre-test, each question in the post-test also had a potential of five points, also scored from zero to five according to the rubric scoring procedure described below. The answers to the questions were recorded on audiotape to be transcribed later. (Rubric is located in Appendix D, the Transcripts are located in Appendix E and the participants scores are located in Appendix F).

**4.2.4 DEPENDENT VARIABLES 2 & 3**

The second and third dependent variables, enjoyment and perceived competence, were measured using existing questionnaire instruments that had already been created and validated. Engagement and enjoyment are considered integral and prerequisite to children’s playful learning (Malone, 1980; Prensky, 2001; Montessori, 1965) and can be measured with the Intrinsic Motivation Indicator Questionnaire (IMI) (Ryan, 2006). This questionnaire was used as a quantitative measure to evaluate each participant’s level of enjoyment and
perceived competence with the *Towards Utopia* learning system. It is generally impossible to directly ask children about their enjoyment and perceived confidence using open ended questions, for many children naturally want to please, and therefore will frequently not give completely authentic opinions to adults or authority figures (Antle, 2008). Therefore, a measurement scale such as a Likert scale was considered to be a potentially more valid measure, especially a Likert scale that had been specifically designed for use by children.

The Likert scale used with the IMI questionnaire was the modified scale explored in the paper entitled, “Endurability, Engagement and Expectations: Measuring Children’s Fun,” by Read, MacFarlane, and Casey, (2002). One of the tools assembled by these researchers was dubbed “The Fun-O-Meter.” Through careful testing, instead of the usual numeric scale from 1 to 5, they decided the optimal images to use to describe the children’s responses to various experiences would be a scale from “Awful,” “Not very good,” “Good,” “Really good” to “Brilliant.” In the Fun-O-Meter, the numeric Likert scale has been replaced with variations of a happy face and can be found in Appendix C.

Read, MacLane and Casey (2002) also devised a schema for a grid to define the children’s enjoyment based on other criteria, such as “Worked the best,” “Most fun,” and “Easiest to do.” This version of the Likert scale, including graphics from the Fun-O-Meter, were used in the scoring of the results for the
second and third dependent variables (enjoyment and perceived competence). This was done to ensure age appropriateness of the questionnaire. The level of enjoyment was measured after each participant had completed their session with *Towards Utopia* learning system using these IMI questionnaire. The level of perceived competence was also measured the same way using these same IMI questionnaire.

**DV 2: Level of Enjoyment.** After the post-test interview, a questionnaire was administered orally to each participant with the goal of measuring the level of enjoyment experienced during their interaction with the *Towards Utopia* tangible learning system.

The instrument used to measure enjoyment was the Intrinsic Motivation Inventory (IMI), which was administered using the modified child-friendly Likert scale described above. The IMI inventory probes for enjoyment. The answers to the questions were recorded on audiotape to be transcribed later. (This data is located in Appendix E)

**DV 3: Level of Perceived Competence.** After the questioning about enjoyment, the IMI questionnaire was further used in the same way to measure the participants’ level of perceived competence related to their interaction with the *Towards Utopia* tangible learning system. The answers to the questions were recorded on audiotape to be transcribed later. (This data is located in Appendix E)
4.3 DATA ANALYSIS

4.3.1 ANALYSIS FOR DV 1: LEARNING OUTCOME MARKING RUBRIC

The learning outcome was analyzed by using a marking rubric which was designed by the educational specialist for this project. The raw data obtained for this measure was collected as answers to a series of open-ended verbal questions, and therefore was qualitative in nature. This raw qualitative data was subsequently converted into quantitative data by use of this rubric. This marking rubric was used to ensure consistency in marking throughout the scoring process. For both the pre and post interview, there were six categories the children’s responses could fall into. The categories in the pre-interview were scored as follows:

5 marks - Description of image includes one or more accurate and pertinent adjectives. There is also an inference related to the content of the images. A concept related to sustainability is also mentioned.

4 marks - Description of image includes one or more accurate and pertinent adjectives. There is also an inference related to the content of the images.

3 marks - Description of photo includes two or more accurate adjectives.

2 marks - Description of image includes one accurate adjective.

1 mark - Description of image is attempted but not necessarily accurate or pertinent to the content.

0 marks - No attempt to describe the image is made.

The categories in the post-interview were scored as follows:
5 marks - Description of image is comparable to pre-learning description, and additionally includes one or more vocabulary words inferred from the voiceover narration. There is also an inference related to the content of the image.

4 marks - Description of image is comparable to pre-learning description, and there are two or more additional descriptors or vocabulary words inferred from the voiceover narration.

3 marks - Description of image is comparable to pre-learning description, and there is one additional descriptor or vocabulary word inferred from the voiceover narration.

2 marks - Description of the image is comparable to pre-learning description, but there is no additional vocabulary inferred from the voiceover narration.

1 mark - Description of the image is attempted but not necessarily accurate or pertinent to the content.

0 marks - No attempt to describe the image is made.

Scoring was based on the participant’s word usage in response to the interview questions. For example, if Participant X had been shown a picture of a farm, and said, “This is a farm where farmers grow food for us to eat and buy at the store,” then Participant X would be scored as 4. This response would be scored as a 4 because the participant has gone beyond the simple word “farm,” and has made the inference about the growing of food in response to the image. This demonstrates they have comprehended the function, meaning and importance of the farm. If the participant had mentioned a key word related to the major concepts communicated by the voiceover, they would have scored 5. However, in this hypothetical case, since he/she hadn’t done so, they therefore
would have received only a 4. In the post-test the same score of 4 would still represent learning gain. For example the use of adjectives changes for the post-test with more specific requirement for word use. For example participant X scored a 4 in the pre-test with more general word usage. In the post-test to receive a score of 4 the participant would be required to add two additional descriptors or vocabulary words that are inferred from the voiceover narration.

The scores from the application of the rubric to the pre and post assessments were analyzed to determine the mean gain and standard deviation for each group (ambient sound: on; ambient sound: off). Since the data was ordinal, a non-parametric inferential test of significant difference was used: the Wilcox Rank Sum test. While the number of subjects in each group was only 15, an inferential test provides a preliminary indication of the effect of ambient sound on learning. Results must be interpreted with caution due to the low number of subjects. A correlation coefficient was also calculated in order to determine if the pre and post test scores were correlated.

4.3.2 Analysis for DV 2: Enjoyment

The numeric responses for the seven enjoyment questions were averaged to create a mean score for each subject. Then, the mean and standard deviation was calculated for each group (ambient sound or no ambient sound) for enjoyment. Likert data is ordinal (interval at best), so the non-parametric inferential test of significant difference was used, the Wilcox Rank Sum test, to
determine if there was a significant difference in the mean responses for enjoyment between groups.

4.3.3 ANALYSIS FOR DV 3: PERCEIVED COMPETENCE

Similarly, the numeric responses for the five perceived competence questions in the IMI were averaged to create a mean score for each subject. Then, the mean and standard deviation was calculated for each group (ambient sound or no ambient sound) for perceived competence. Likert data is ordinal (interval at best), so the same non-parametric inferential test of significant difference was used, the Wilcox Rank Sum test, to determine if there was a significant difference in the mean responses for perceived competence between groups.
CHAPTER 5: RESULTS

In this chapter, the results of the study will be presented. The central research question of this study was: Does ambient sound promote increased engagement in learning? The following hypothesis was tested:

Ambient sound increases engagement which results in improved learning. The use of ambient sound will effect learning outcomes by making learning deeper and richer. Children will be more engaged with the TUI and therefore ambient sound will help the child engage with the content.

5.1 LEARNING RESULTS

The experiment was designed to provide evidence that ambient sound enhanced learning. This was accomplished by comparing two groups: Group 1 (ambient sound: on), and Group 2 (ambient sound: off). There was a total of 30 participants in the study, 15 with ambient sound, 15 without ambient sound. The raw learning outcome data is displayed in the Appendix B.

5.1.1 DESCRIPTIVE STATISTICS SUMMARY

The mean pre-test score for the ambient sound condition was 47.0 out of a possible perfect score of 78.0 and the standard deviation was 9.0. The mean pre-test score for the non-ambient sound condition was 46.7 of 78.0 and the standard deviation was 8.0.
The mean post-test score for the ambient sound condition was 65.1 of 78.0 and the standard deviation was 8.3.

The mean post-test score for the non-ambient sound condition was 63.6 of 78.0 and the standard deviation was 11.7.

The mean difference between pre and post test scores for the ambient sound: on (group 1) was 18.1. Since the number is positive, it indicates an improvement or gain in learning.

The mean difference between pre and post test scores for the ambient sound: off (group 2) was 16.9. This also represents a gain in learning score.

5.1.2 INFERENTIAL STATISTICS SUMMARY

The Wilcoxon Rank Sums test of significant difference indicated that there was no significant difference on the post learning scores between the ambient sound and non-ambient sound condition as measured on their post-task interviews ($z = 0.02078$, $p = 0.9834$).

The Wilcoxon Rank Sums test of significant difference indicated there was no significant difference between the two groups in their achievement difference between pre and post interviews ($z = 0.12474$, $p = 0.9007$).

A higher gain score for the ambient sound: on group relative to the ambient sound: off group would have been considered evidence for increased effectiveness of learning in the ambient sound group, and therefore the test of the research question and hypothesis one. However, no significant difference was
found. Therefore, the results do not support the hypothesis that ambient sound increases the effectiveness of the *Towards Utopia* learning system.

### 5.1.3 Correlation Between Pre & Post Test

The correlation between the pre and post test was $r=0.033$, indicating a weak correlation.

### 5.2 Enjoyment

A goal of the research was to determine whether ambient sound enhanced engagement. As discussed in chapter 2 and 3, since no valid instrument for directly measuring immersion or engagement was available, the level of reported enjoyment was used as an *indirect* measure of engagement. Therefore, the first group (ambient sound: on), and the second group (ambient sound: off) were compared with each other in terms of reported levels of enjoyment.

#### 5.2.1 Descriptive Statistics Summary

The mean score for the ambient sound condition was 4.4 out of 5.0 and the standard deviation was 0.4.

The mean score for the non-ambient sound condition was 4.2 out of 5.0 and the standard deviation was 0.6.
5.2.2 INFERENTIAL STATISTICS SUMMARY

The Wilcoxon test of significant difference indicated that there was no significant difference between the two groups in their enjoyment ratings in the ambient sound and non-ambient sound condition ($z = -1.75106, p = 0.0799$).

A higher level of reported enjoyment in the ambient sound: on group relative to the ambient sound: off group provides weak support for the notion that ambient sound can increase the level of engagement. Such a pattern does support my hypothesis. However, more data is necessary before claims can be made that that ambient sound increases engagement.

5.3 PERCEIVED COMPETENCE

A goal of this research was to determine whether ambient sound enhanced engagement. Since no valid instrument for directly measuring engagement was available, the level of perceived competence was used (along with enjoyment, since the two are related) as an indirect measure of engagement. Therefore, the first group (ambient sound: on), and the second group (ambient sound: off) were compared with each other in terms of reported levels of enjoyment.

5.3.1 DESCRIPTIVE STATISTICS SUMMARY

The mean score for the ambient sound condition was 3.8 out of 5.0 and the standard deviation was 0.3.
The mean score for the non-ambient sound condition was 3.3 of 5.0 and the standard deviation was 0.6.

5.3.2 INFERENTIAL STATISTICS SUMMARY

The Wilcoxon test of significant difference indicated that there was no significant difference between the two groups in their perceived competence in the ambient sound and non-ambient sound condition \((z = -1.68115, p = 0.0927)\).

The results for the reported perceived competence responses in the ambient sound: on group relative to the ambient sound: off group shows some support for the notion that ambient sound can increase children’s feelings of competence which may in turn support engagement and learning.

5.3.3 CORRELATION BETWEEN ENJOYMENT & PERCEIVED COMPETENCE

The correlation between the enjoyment and perceived competence scores was \(r = 0.04\), indicating a weak correlation.

5.4 OTHER RESULTS

5.4.1 COMPARISON OF ENJOYMENT & PERCEIVED COMPETENCE

The Wilcoxon test of significant difference indicated that there was a highly significant difference, at the \(\alpha=0.001\) level, between enjoyment and perceived competence in the ambient sound group \((z = -4.08559, p = 0.001)\).

Similarly, the Wilcoxon test of significant difference indicated that there was a highly significant difference at the \(\alpha=0.001\) level, between enjoyment and
perceived competence in the non-ambient sound group ($z = -4.56259, p = 0.001$). In both groups, children reported higher ratings of enjoyment than perceived competence.

5.4.2 COMPARISON OF PRE & POST TEST SCORES

The Wilcoxon test of significant difference indicated that there was highly significant difference, at the $\alpha=0.001$ level, between the pre and post test scores for the ambient sound group ($z = 3.46342, p = 0.0002$).

The Wilcoxon test of significant difference indicated that there was significant difference, at the $\alpha=0.0001$ level, between the pre and post test scores for the non-ambient sound group ($z = 3.98189, p = 0.0001$).

Significant improvement was achieved by both groups, which can be interpreted as evidence that the participants attained a fuller and deeper understanding of sustainability concepts as a result of their interaction with the Toward Utopia tangible system. In addition, this result indicated that while ambient sound did not improve learning outcomes, it did not interfere with learning either.

5.4.3 COMPARISON BETWEEN GENDERS ON LEARNING GAIN

Neither group (ambient-sound: on, ambient sound: off) showed a significant difference in learning gain between genders. There was no gender effect, indicating the Toward Utopia design was effective in supporting both boys and girls to learn about basic sustainability concepts.
5.5 SUMMARY

In terms of the research question and its associated hypothesis, the results do not support the hypothesis that ambient sound increased the learning effectiveness. It does show weak support for higher enjoyment and perceived competence ratings with the educational material in the ambient sound group.

The data does indicate that children’s experience with the Toward Utopia tangible system did significantly increase their understanding of sustainability concepts. The results also indicate, more importantly, that ambient sound did not interfere with learning and may have helped with enjoyment and perceived competence.
CHAPTER 6: DISCUSSION & DESIGN IMPLICATIONS

This chapter contains a discussion related to the research question: Does ambient sound promote increased engagement in learning?

In addition I address the theoretical and practical considerations which informed the design of the Towards Utopia research instrument.

6.1 RESULTS DISCUSSION

The results for the experiment indicate that there was no additional benefit to using ambient sound in relation to learning pedagogical content. In addition it shows that using ambient sound does not improve or interfere with learning... and it may make the experience more enjoyable and increase the participants feeling of perceived competence.

Let us consider each of the three dependent variables in turn.

6.1.1 LEARNING OUTCOME

Learning did occur for both the ambient sound:on and ambient sound:off groups. A significantly greater improvement in the ambient sound:on group relative to the ambient sound:off group would have been required in order to support the hypothesis that ambient sound improves learning. Since no such statistically significant difference was found between the pre test and post-test interviews of these two groups, no support for this hypothesis can be claimed.
6.1.2 LEVEL OF ENJOYMENT

There was weak support for the notion that ambient sound increases the level of engagement. The ambient sound:on group reported slightly more enjoyment over the ambient sound:off group. This enjoyment result is not statistically significant.

6.1.3 LEVEL OF PERCEIVED COMPETENCE

There was no significant difference between the ambient sound:on group and the ambient sound:off group with regards to perceived competence.

6.2 THEORETICAL IMPLICATIONS

In this section, we shall briefly consider the results of the study in terms of the main theories discussed in Chapter 2.

Conflicting theories exist about the role sound plays in the cognitive process of learning. Generally speaking, claims made by authors such as Bolas (Pimental & Teixeira, 1993, p. 150-154; Chion, 1994) predict the addition of ambient sounds should improve the memory of the program material. In contrast, the claims of theorists and researchers as Mark (1992) and Mayer and Moreno (1998) predict that sound can interfere with learning though the redundancy principle. The overall pattern of the results cannot be said to have been consistent with either of these two general claims. The first set of theorists predicts the addition of ambient sound should have significantly improved
learning of the material. However, since this did not happen, it cannot be claimed that the data supported this formation. Conversely, the second group of theorists predict the addition of ambient sound should have significantly decreased the learning of the program material, and this also did not occur. Therefore, we cannot say this group of theories was supported by the findings of this study either.

### 6.2.1 DEPTH OF PROCESSING THEORY

One prominent model of human memory maintains the encoding of memory depends on the depth of mental processing (Craik & Lockhardt, 1972). This model maintains that when people can relate meaningfully to the information presented to them, they can embed it more deeply into memory, and therefore are more likely to be able to recall the information. It was anticipated that the addition of ambient sound into the program would cause the information to be processed in a somewhat deeper and fuller way than it otherwise would have been, and thus be remembered better.

However, since there was no evidence for such an effect, from this theoretical perspective, the implication would be that the sounds used in the experiment were not of a sort that stimulated such a deeper level of processing, and therefore did not lead to increased learning and retention of the material. If the sounds used in this experiment were insufficient to activate a deeper level of processing, this raises the question of what other types of sound might have
done so? Higher volume? Different content? Greater realism? A higher level of meaningfulness?

6.2.2 DUAL CODING THEORY

Theorists such as Paivio (1986) and Sweller (1994) claimed that both auditory and visual information are sent to the brain along two different and distinct channels, and then processed by the brain separately (split-attention principle). The theory posits that because the information is separate and distinct, there is greater potential for learning when both auditory and visual information are presented.

However, this theory also raises the opposite possibility – the potential that if the information received by the brain is too similar or redundant, i.e., voiceover narration and text on the screen convey precisely the same information, the two channels may “compete” with or interfere with each other, and learning could therefore be decreased (redundancy principle). It is therefore theoretically possible that the addition of ambient sound does not interfere with processing in the brain and does not trigger the redundancy principle, and therefore does not interfere with learning.

6.2.3 MEMORY TRACES

Memory trace theory posits that new information is better comprehended and learned when other memories are activated by long-term memory (Atwood, 1989; Kieres, 1978). New information can be more easily assigned to related long
-term memory paths, thus reinforcing the paths through some physical alteration within the brain. The implication for multimedia and tangible interfaces is that a memory trace consisting of verbal, visual and auditory information would be easier for the brain to retrieve than information presented through only a single modality. Theoretically, information presented in a multisensory way will create a larger “trace” in the neural pathways of the brain and create deeper learning.

Considered from this theoretical perspective, the absence of enhanced learning as a result of ambient sounds could be interpreted as meaning the sounds were not vivid enough, impactful enough or intense enough to evoke sufficient attention to create a “larger” memory trace. Perhaps if other types of sounds that did possess such qualities had been used, the enhancing effect of learning would have been observed.

6.2.4 EMOTIONAL IMPACT

Another related theory maintains that the evocation of emotion is a very important factor in learning and memory (Lang, 1979; Shiekh & Jordan, 1983). The strength of emotional connectedness to stimulus affects the depth of learning. Therefore, affect is an important consideration in the design of educational multimedia. In addition, images that evoke a stronger emotional response will probably be more memorable than those which evoke a weaker emotional response. The implications for tangible interfaces is that adding ambient sound auditory channels to learning environments can potentially
increase the emotional response and increase the memorability of the experience leading to deeper learning.

Furthermore, if we consider the failure of the ambient sounds to produce any enhancement of learning from this theoretical perspective, the implication is that the sounds used in this experiment must not have been of a sort that evoked a sufficient emotional response.

6.2.5 SUSPENSION OF DISBELIEF & IMAGINATIVE IMMERSION

This has been said best by Coleridge (1817), “that willing suspension of disbelief for the moment, which constitutes poetic faith.” Suspension of disbelief requires a surrender to the content, with the viewer therefore forgetting that they are watching something as a viewer and not as an active participant. It was this concept of suspension of disbelief serving to increase engagement and enjoyment, and the possible increase in engagement being supported by ambient sound, that this paper attempted to explore.

If we consider the results of the experiment in the light of Coleridge’s notion of suspension of disbelief, the implication is that the sounds used in this experiment simply were not of a type that encouraged suspension of disbelief. Perhaps there are some other kinds of sounds that would more effectively capture the imagination and encourage suspension of disbelief?
6.3 DISCUSSION ON DESIGN

Everything depends upon the quality of the experience which is had. The quality of any experience has two aspects. There is an immediate aspect of agreeableness or disagreeableness, and there is its influence upon later experiences. Hence the central problems of an education based upon experiences is to select the kind of present experiences that live fruitfully and creatively in subsequent experiences. (Dewley, 1997, p. 26-27)

6.3.1 IMPORTANCE OF ENGAGEMENT & ENJOYMENT

Enjoyment within an experience is extremely important, for it lays the foundation for future knowledge acquisition. The goal, then, in design, is not just to get the information across, but to get it across in such a way as to support future learning. This is precisely where TUIs are useful: information is presented in such a way that the experience will be remembered for its tactile quality, as well as for its content, and especially for its level of enjoyment. The IMI data indicated that a tangible learning systems was enjoyable for children to use. The ambient sound: on group’s mean score was 4.4 out of 5 and the ambient sound: off group’s mean score was 4.2 out of 5.

My hope is that this experiment will lead the way towards more exploration into the use of ambient sound in tangible interfaces. Sound design should be a central component to the design of the interface and not avoided or tacked on later as an afterthought.

Perhaps we could create and use a framework that measures the strengths and limits of any given medium in terms of ambient sound for e-learning? More,
research is needed to understand what “good design” is and how this knowledge can be applied to educational contexts. And finally, where does all of this fit into the educational technologies currently available to educators? What are the limits of the technologies (if we presume to have reached the limit)?

**6.3.2 DESIGNING "NOVEL" EXPERIENCES**

*Science World* was an excellent venue for the random sampling of children. Our age group was well represented, with a fair balance of girls and boys. Both genders did equally well with the interface and self reported evenly on enjoyment and perceived competence.

All the children self reported a high level of enjoyment with the *Towards Utopia* tangible learning system but felt a lower level of perceived competence with the system. This is interesting since I believe this was as a result of the learning system being a novel experience.

“It made me think about things a little more. I liked planning out how the world could be a better place.” (Participant #30)

Feedback from one of the participants suggested that some deeper learning may have occurred. Such feedback is useful in trying to determine if these types of experimental interfaces have educational value.
Technologies shape us, but this is not a new phenomenon. A similar “novel” technology was introduced into western culture a few centuries ago. The Gutenberg printing press was novel, and has turned into an indispensable way to disseminate information. Perhaps computer technology (as an extension of electricity), in forms such as tangible interfaces, will continue to allow us to interact with information in a fun and educational way. The possibilities for this technology appear to be endless.

6.3.3 REFLECTION & PERSONAL OBSERVATIONS

This section contains my personal and anecdotal observations. This section is all in the realm of the intuitive, where the designer “just knows” based on her/his experience. I’ve included this section because I hope some of my insights and observations may be of benefit to other designers working on similar projects in the future.
6.3.4 THE CONCEPT OF TOWARDS UTOPIA

The concept of the Towards Utopia came about while I was still an undergraduate student. (Figure 1.10)

Figure 1.10, Towards Utopia Early Concept Drawing.

This project emerged from a real concern for the future welfare of our planet. For my prototype, I wanted to work on something that had to do with sustainability. I decided since I needed to design something, it may as well be something that I felt passionate about. This project therefore stitched together a menagerie of very different interests: multimedia, tangible computing, cognition, learning, media theory, and, of
course, sustainability. Displayed below are two early conceptual drawings. (Figures 1.11 and 1.12)

Figure 1.11 Early Conceptual Drawing
Figure 1.12 Early Conceptual Drawing
6.3.5 OBSERVATIONS

The feature I most enjoyed about this project was that it created an opportunity for dialog about issues concerned with sustainability. During the course of the research, many people approached me, saying they were passionate about recycling, bicycling, resource conservation, hiking, ecological preservation and other issues related to sustainability.

Parents were often very eager to have their children engage with the Towards Utopia tangible system. I don’t think I would have received such an enthusiastic response if my project was not centred upon a topic which touched so many people so deeply. In addition, the first weekend of testing corresponded with Earthhour (World Wildlife Foundation’s attempt to raise awareness and demonstrate solidarity and action about climate change). As a result, I was able to hand out flyers to parents to help raise awareness. Parents were often enthusiastic about having their children learn about sustainability. They were so interested in doing so that after we had already met the quota of children needed, we still had parents approaching the table to sign their children up for the experiment.

One parent, an educator of grade four students, expressed a strong desire to have me come to her class to test her children on the understanding of sustainability issues. She loved the sustainability concept and the physical
interaction component, and she was interested in the kinesthetic aspects of the interface. In addition, two Science World staff members were very excited about the interface and about the sustainability concept.

There was a constant rotation of children through the site, and the snack table was an essential component of the experiment. It kept the children occupied and happy while they waited for their session with the interface. I will definitely include such a snack table in any additional experiments that I may conduct with children in the future, and would highly recommend such a feature to others who design similar types of projects. It really seems to keep the children grounded and patient!

The speculation that children would role-play during the experiment did not materialize. Being a mother of a preschool child, I incorrectly assumed that children would welcome any opportunity for role playing and dress-up. However, this clearly turned out to be an incorrect assumption. The lesson learned seems to be DON'T MAKE ASSUMPTIONS. Children between seven and ten of years of age did not wish to wear a costume for the interactive activity. This self-consciousness might have been minimized if each child did not see any peers during his/her turn at the interface. But since the experiment was so popular, with other children waiting in the wings, it was impossible to create a peer-neutral environment.
6.3.6 TECHNICAL PROBLEMS

There were a multitude of problems encountered with the eraser. At times, it could be frustrating for both for the children and the researchers. The eraser was a physical stamp (with fiducial) that was used to erase or reposition other graphics. For the most part, the eraser did work, but occasionally it required a corrective intervention by the technician. On several occasions, a computer restart was required. I even changed the eraser-stamp fiducial to rule out problems with that particular stamp, but the eraser still sporadically wouldn’t erase. Speculation by the technician was that distortion caused by the fish-eye camera was the likely culprit. Even so, repeated attempts to fix the problem were not successful. This glitch was not detrimental to the actual experiment since all participants had the same experience with the eraser.

6.3.7 SOUND CONTAMINATION

Perhaps the most frustrating aspect of the experiment was a result of it having been conducted inside a children’s science museum. Such museums are wonderful, but noisy places. Children are enjoying themselves in loud and exciting ways. Even though we were inside a self-contained room, there was minimal soundproofing and some sound from other exhibits did bleed through the walls. We needed to keep the volume sufficiently high on the tangible interface in order dampen out the cacophony of other sounds. This cascaded into other problems. The door to the space needed to be lowered in order to keep the
sound out as much as possible. Much like a garage door, it made a great deal of noise, and this caused apprehension in some of the children. Such sudden noise and apprehension may have broken their concentration and potentially disrupted the sequence of mental events necessary for the creation sensory and/or imaginative immersion and active engagement. For an experiment with the main goal of evaluating the subtle aspects of auditory stimuli, such an environment turned out to be problematic. The presence of all this distracting, unpredictable and unanticipated auditory stimulation may at least partially explain why there was no statistical difference observed between the two groups. The ambient sound, although present in the interface, may not have been “present” enough to make a difference during testing. Any future research of this type must be conducted in an environment in which much more rigorous control over extraneous auditory stimuli can be maintained.

6.4 GENERALIZABILITY OF RESULTS

The Towards Utopia experiment is not generalizable to other age groups. Each child’s age is uniquely suited to particular learning styles and cognitive abilities. Therefore any experiment regarding learning and children must be directed right to the target age group. No extrapolations to other age groups can be inferred from this experiment.
6.5 LIMITATIONS OF THE STUDY

Being a master’s thesis project, there were many limitations to my experiment that possibly affected the validity of the study. First and foremost was the lack of a sound designer on my team. Although I did consult a sound designer during the planning phase, I did not employ them for the building and testing of the prototype.

I wore many hats in the planning, design, production and testing of the Towards Utopia tangible system, and may have sometimes lost my objectivity. The educational specialist and my senior supervisor did a great job of keeping me on track!

6.5.1 SOUND BLEED

It is important to note that this paper explores very illusive idea around engagement and enjoyment that is hard to quantify. There were also confounding variables that were impossible to control in the actual implementation of the study. It is important to note that the space used for the experiment included some unanticipated sound bleed issues. The physical space was located inside a self-contained room (without Wenger soundproofing) in a very chaotic and cacophonic children’s science museum with many noisy exhibits. Since this was a study about whether ambient sound could create engagement and deeper learning, sound was an important consideration in this experiment. It was hoped that the volume of the audio in the Towards Utopia
learning system was sufficiently loud enough to create a degree of immersion and engagement with the tangible user interface, and that this would compensate for some sound bleed issues.

However, it is possible the increased volume of the program material was not sufficient to overcome the effects of the noise bleed, and that the sound contamination from the science museum space contributed to the lack of measurable difference between the sound:on and the sound:off group. It is also important to consider that even if I tested in a regular classroom environment there would still be lots of ambient noise. The only way to avoid potential confounding variables would have been to run the experiment inside a very large Wenger acoustically soundproof room.

It is also important to note that although there were some sound bleed issues, it was not a fatal flaw to the experiment. I was easily able to transcribe the audio tapes of the interviews with the children and many of the children spoke quite softly. Had the sound bleed issues been severe this would not have been possible.

6.5.2 LIMITED SAMPLE SIZE

The sample size was small: 15 participants in the ambient sound: on group, and 15 in the ambient sound:off group. With a larger sample, there might have been a measurable difference observed between the groups.
6.5.3 LIMITED TIME

The experiment was short in duration. Most participants spent less than ten minutes creating their sustainable community. There were only 13 questions administered in both the pre and post interview. Since this was a relatively short experiment, it is possible there was not enough time to establish sensory immersion with the interface and therefore imaginative immersion. A typical dramatic television show episode lasts 30 minutes, and most movies last more than an hour. A key ingredient to the incubation of imaginative immersion may well be allowing sufficient time for it to develop. If a longer time interval had been tested, perhaps a more robust effect might have been detected.

6.5.4 LONG-TERM EFFECTS

There was no provision for a follow-up study. There is therefore no way of establishing if the learning about sustainability issues represents a long-term effect or not. There is also no way to know if the learning acquired from the experience with the *Towards Utopia* interface will transfer to other areas and issues.

6.5.5 LATENT VARIABLES

Although everything possible was done to constrain the variables, testing for the effects of ambient sound as a means for enhancing the suspension of disbelief is a complex and elusive endeavour. A major factor which makes the task so difficult is that there simply is no way to quantitatively measure
suspension of disbelief, active creation of belief, imaginative immersion or even engagement. We know people experience such states, (or at least something like them), but I was unable to discover any existing credible scientific way to quantify such experiences.

In hindsight, I would have liked to have been able to recruit more subjects and do a follow up study since I still feel I am on to something. As it stands, I have no definite evidence that ambient sound leads to deeper learning. However, there is still the glimmering possibility that the participants in the study learned more deeply than they might have done without exposure to ambient sound. However, as it stands, I have no evidence of such an effect.

The fact there was no measurable difference observed between ambient sound:on and the ambient sound:off groups with regard to learning outcomes should not obscure the fact that my quantitative data did show significantly higher achievement in the post-interview than the pre-interview. At the very least, I was able to demonstrate that tangible user interfaces support the learning of pedagogical content.

The research showed no statistical difference in learning outcomes, but it did appear that using ambient sound makes the learning experience ever so slightly more enjoyable, and that participants that went through the experiment with ambient sound reported a slightly higher level of competence with using the learning system. To get at the mechanisms of ambient sound in relation to engagement and enjoyment. Additional studies should include more qualitative
measures such as open ended interview questions that are analyzed thematically. This is a difficult prospect with children, in that they aim to please authority figures and tend to provide only provide positive feedback. So mechanism for getting around these issues would be required.

In addition, my research demonstrated in a circuitous way that ambient sound does not interfere with the cognitive processes such as depth of processing effect and dual channel coding. Contrary to the concerns raised by the work of some authors (Naijar, 1992), there does not appear to be any harm in using ambient sound in tangible user interfaces with educational purposes since it does not appear to interfere with learning.

Based on the results from this experiment, learning did occur, but there was no statistically significant difference between the two groups with regards to the use of ambient sound. Ambient sound did not appear to facilitate learning, but ambient sound also did not hinder learning either. Therefore, the design implications of this experiment are that there is no reason to avoid using ambient sound for future TUIs since it has been determined that the use of ambient sound is not detrimental to learning and may improve the overall experience. What I wish to convey to other designers, instructional designers, and developers is ... ambient sound won’t hurt, and it may well make the experience more engaging and enjoyable.
6.5.6 RICHNESS OF RESEARCH INSTRUMENT

Another limitation for the experiment was the richness of the research instrument. Being a graphic designer, I design things, I know no other way and my designs are visually interesting and enjoyable.

It is entirely possible that the richness of the research instrument made it more difficult to tease apart whether ambient sound increased learning on the post test because it may have introduced confounding variables. There is no way to know for sure since, there is no standardization on how to develop effective multimedia instructional content for learning. Therefore, there was no standard to draw upon when creating tangible multimedia content. In addition since there was no difference between the ambient sound:on and ambient sound:off groups I doubt that the visual richness had any effect.
CHAPTER 7: CONCLUSIONS

This thesis has explored the ideas related to sensory immersion, suspension of disbelief, imaginative immersion and engagement, and how this plays out in children’s enjoyment with the Towards Utopia tangible system. It has attempted to gauge whether ambient sound improves the learning outcomes for children with regards to the teaching of sustainability concepts. This research also revealed that there are no standards to rely upon with regards to the use of ambient sound in tangible user interface design.

7.1 THE AIMS OF THIS RESEARCH

To attempt to get at the mechanisms of imaginative immersion and the implications for a deeper learning based on engagement and enjoyment.

To establish the importance of ambient sound in tangible interfaces and to raise awareness for the possible use of ambient sound in a pedagogical context.

To apply this knowledge towards the actual design of a tangible user interface that emphasized ambient sound.

The introduction defined the areas of interest within an educational context with regard to ambient sound as a mechanism for encouraging imaginative immersion. The basic supposition was that ambient sound would
encourage deeper immersion, engagement and enjoyment with the Towards Utopia learning system. It also defined a method of exploration into the research question: Does ambient sound promote increased engagement in learning? This question was explored and tested through subsequent chapters.

In Chapter One I introduced the concept of sustainability and the urgent need for education on sustainability. It also introduced the concept of multimedia learning and the possibility of using ambient sound as a mechanism to create a deeper level of engagement and learning. In Chapter Two I reviewed existing literature on ambient sound, suspension of disbelief, immersion, engagement and cognitive load theories. In Chapter Two I discussed the potential usefulness of ambient sound in the design of tangible interfaces in an educational context. In Chapter Two I further illustrated the possibilities of using ambient sound in education materials and makes correlations with entertainment media. In Chapter Three I discussed the methodology used to address the research question and provides a framework for the design of a mixed method experiment. In Chapter Four I introduced the venue, experimental apparatus, physical space and evaluation instruments that were used. It also described the procedure for the experiment, and explained how the data was collected and analyzed. In Chapter Five I described the results of statistical analysis of the tests related to the use of ambient sound in the Toward Utopia interface. In Chapter Six I discussed the design implications for the design of tangible interfaces and the use of ambient sound. In this final chapter I
discussed the implications of this research and future directions made possible by this knowledge.

More research is needed to understand the implications of engagement in TUI design and the role ambient sound plays in the creation of immersion, engagement and enjoyment. The entertainment industry does an excellent job of creating immersive and engaging experiences. It is therefore worthwhile to examine the entertainment industry for tools and frameworks to facilitate active engagement when creating educational technologies. Since education is a relatively small market compared to the entertainment industry, it may be valuable to investigate the entertainment industry in order to discover clues, useful concepts and superior approaches to enhancing learning in an educational context. Many methods used in entertainment could be transferred to educational contexts if we could only discover what designers, directors, producers, etc. already know based on experience. What is it exactly that leads a person into imaginative immersion? And what is that magic ingredient that creates an immersive experience that is engaging and enjoyable? How can we create richer learning experiences by utilizing techniques already at play in the entertainment industry? Where does the use of new and novel technologies intersect with educational pedagogy?

Children at science museums are naturally attracted to the “novel” experience. In fact, children expect novel experiences when they go to such
places. However, does this “novelty” play out as actual value in terms of contributing to sustained learning?

Many questions gathered around the technological novelty aspect of the experiment. How does the seduction of technology and its novelty factor play into the children’s engagement and enjoyment? Is enjoyment dependent on the novelty of the experience? Does true learning occur or are the children merely seduced momentarily by the technology? Can improvements in learning be sustained even if the technology is around for a while (which rarely happens in our technological society)? I don’t have the tools to answer any of these questions. This would be ideal material for further exploration.

7.2 FUTURE WORK

Because this is a preliminary investigation it would be interesting to see if:

1. Having a larger sample size would have an impact on the learning outcome.
2. Selecting other ambient sound files and comparing this group of sounds to ascertain if there is any impact on the learning outcome.
3. It would also be interesting to see if any additional sounds or layering of sounds would enrich the experience.

As for TUI’s we still need to understand how adding tangible interaction might interfere with the visual haptic processing centre of the brain. This was touched on with this research and other research as well but this needs to be more fully explored.
Towards Utopia is a journey, not an endpoint. The main goal is to create an interface that could be applied towards a better future – not a dystopian future as portrayed by much of the media, but a future where we can all work together to foster a more sustainable way of life. The interests expressed in this paper include the intersection of media, technology, and global stewardship: a virtual crossroad between entertainment and education. Exploring the tactile interface between human and computer plays out in these interests. The hope is that through creating a tangible “Utopia,” space for a dialogue geared toward a better future could be created: a utopian future in which we learn to keep things in balance, respecting our world and the people around us.
APPENDIX A: TU - INTERACTIVE VOICEOVER NARRATION

E = Engineer, D = Lucky Ducky

E: “SUSTAINABILITY: Development that meets the needs of the present generation without compromising the ability of future generations to meet their needs. It's the use of natural resources in a manner that does not damage or deplete it. It's the balance between nature and development.”

E: “Hi Friends, welcome to “Towards Utopia.” This is my good friend, Lucky Ducky” D: “Hi kids, I'm going to get you to come through my home.”

1. TREES/NATURE:
Trees represent nature and nature (ecological) reserves. They are places that birds and animals can seek protection and solitude. Represented by any of various shrubs, bushes, or trees.

D: (HAPPY): “My tree! This is my shelter, my home. Here is where I feel protected, safe. I love my home!”

2. NATURE RESERVE:
The natural place where animals live, including all the environmental factors (food, water, space and shelter) that animals require to survive and thrive. We need nature because animal need; food, water, space and shelter in order to survive.

D: “My forest! This is where I find my food and water. Trees are my shelter, my protection. I have lots of space to roam (flap feathers).”

3. WETLANDS/MARSH
Land set aside where the water is near the surface of the land; not quite water or land. Wetlands perform important functions, such as providing a habitat for birds and filtering waste and contaminants.

D: “My swampy wetland! I'm wet and feeling wonderful! This is where I spend most
of my time with my other bird friends. Because there are yummy bugs for me to eat.”

4. INDUSTRY:
A building or group of buildings with facilities for the manufacture of goods. Industry represents the necessary amount of human activity required for a society to function, i.e., the building of cars for people to drive, manufacture of paper for comic books, food processing and packaging.

E: “Here’s where we make stuff; it's a factory, a place where things are built. Like toys, comic books & candy.”

5. COMMUNITY GARDENS:
Farming that meets the food needs of the city dweller, but does not generate food for stores.

D: “I sometimes fly by these places, and I can stop in and have a rest. Sometimes I take a dip in the bird bath.”
E: “This is a good place to grow veggies for the people who live around here.”

6. FARMS:
Farming to meet the needs of society on a regional level.

D: “Farms also have animal friends for me.”
E: “Here's a lot of space where they can grow a lot of food.”

7. RENEWABLE ENERGY:
Energy produced from sources such as the sun, wind and moving water.

E: “These are ‘clean’ ways of making energy. They don't leave a dirty mess.”

8. NON-RENEWABLE ENERGY (COAL/GAS):
It is energy that is generally cheaper but is not clean energy. This energy is non-renewable that once gone is gone for good.

E: “This is the kind of energy that you can only use once; we find it, we use it, then it's gone.”
9. A SINGLE FAMILY DETACHED HOME:
A free-standing residential building. Built on a lot larger than the building, creating a yard.

E: “This is a home for only one family. There’s a lot of land around it and it takes up space.”

10. TOWNHOUSE:
An attached dwelling where there are multiple owners. Generally, they require a smaller footprint and allow people to be closer to shopping and business.

E: “These are homes for one family but built right beside a home for another family. The yard is small and there is shared space for a playground.”

11. APARTMENT/CONDOMINIUM:
High-density buildings. Many people live in the same building but in separate units.

E: “This is where I live. It’s not as big as a house but it has everything I need. I live really high up because my home is tall and it doesn’t use a lot of land space.”

12: ROADS:
Asphalt or concrete. Dense material that supports the weight of cars and trucks. It’s also a means of transportation.

E: “We build roads and we need them, but they take up a lot of space, and are expensive because they always need fixing.

13: RETAIL BUSINESS:
Toys, clothing, food stores for the people living in a community.

E: “Stores! Where you can buy everything you need. Like groceries, toys, books and video games.”

OUTCOME SCENARIOS:
D: “No Flooding”, “Some Flooding”, and “Lots of Flooding.”
APPENDIX B

Questions asked were: Tell me what you know about this.
Anything else?

RAW DATA FROM THE TESTING OF THE TOWARDS UTOPIA TANGIBLE SYSTEM

AMBIENT SOUND ON (GROUP 1):

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<th>Difference</th>
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<td>Totals n=</td>
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APPENDIX C: PERCEIVED ENJOYMENT & PERCEIVED COMPETENCE FOR THE TWO GROUPS

Not true at all  Not very true  Somewhat true  True  Very true

1. While I was working on the sustainability activity I was thinking about how much I enjoyed it. (Interest/Enjoyment)
2. I think I was pretty good at the sustainability activity. (Perceived competence)
3. I found creating a sustainable environment very interesting. (Interest/Enjoyment)
4. I think I did pretty well at the sustainability activity, compared to others. (Perceived competence)
5. Doing the sustainability activity was fun. (Interest/Enjoyment)
6. I enjoyed the sustainability activity very much. (Interest/Enjoyment)
7. I thought the sustainability activity was very boring. (Interest/enjoyment)(R)
8. I am satisfied with my performance on the sustainability activity. (Perceived competence)
9. I felt pretty skilled at the sustainability activity. (Perceived competence)
10. I thought the sustainability activity was very interesting. (Interest/Enjoyment)
11. I would describe the sustainability activity as very enjoyable. (Interest/enjoyment)
12. After working at the sustainability activity for awhile, I felt pretty competent. (Perceived competence)
<table>
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<th>GROUP 1</th>
<th>Perceived Competence</th>
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**GROUP 2**

**Total** = 439 (29/35)

**GROUP 2**

**Total** = 346 (23/30)
### A: Pre-learning description

Description of photo includes one or more accurate and pertinent adjectives. There is also an inference related to the content of the photo. A concept related to sustainability is also mentioned.

### B: Post-learning description

Description of photo is comparable to pre-learning description, and additionally includes 1 or more vocabulary words inferred from the voiceover narration. There is also an inference related to the content of the photo.

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APPENDIX E - PRE & POST INTERVIEW TRANSCRIPT

MARCH 28 - PARTICIPANT 1
A1. That's a forest; it looks a bit like the maja jungle.
A2. Person has something in her hands, and she walking in the woods.
A3. This is a nest, and it's a lake.
A4. It's a factory, there's smoke or something coming out of the big tower things.
A5. Looks like a garden, looks like a garden....
A6. Looks like an abandoned shed, it looks like it's in the country.
A7. It's a wind turbine, lot of them in California and Denmark.
A8. It looks like something like a power plant.
A10. Looks like an apartment, it is like a house/apartment.
A11. It looks like a high rise.
A12. Probably in Toronto, and it's rush hour.
A13. This is a Canadian Tire store.
B1. It's a forest, with lots of trees, and space for animals to live.
B2. It's a path where people can walk in forests.
B3. It's a swampy place where birds like to be, they can eat stuff there.
B4. It's a factory where stuff is made, it's not good really very much.
B5. It's a garden where birds can rest.
B6. It's a farm where animal grown and....
B7. It's a turbine energy producing place.
B8. It's a power plant that make energy, but it pollutes the air.
B9. This is a place where one family lives.
B10. This is a townhouse place, where lots of people live.
B11. This is a big apartment space where everyone lives.
B12. This is a road that takes up a lot of land.
B13. This is a bunch of stores where you can buy thing, but it takes up a lot of room.
MARCH 28 - PARTICIPANT 2
A1. Forest, one of the trees is black.
A2. Walking in the forest.
A5. Home, garden...n, trees.
A6. Barn, looks like it is abandoned.
A7. Wind energy, clear skies.
A8. Refinery of some sort.
A9. House, looks like a....
A11. Big city, city skyscrapers all around, 20 stories.
A12. Traffic in the winter, Vancouver.
A13. Canadian Tire, winter, Marks Work Warehouse.
B1. That's where the duck lives, lucky ducky, nature.
B2. Nature, that's his home, there's a person in there.
B3. Nest, I think, earth.
B4. Farm, a lot a smoke.
B5. That's where ducks can rest, there's vegetables.
B6. There's a farm, lucky ducky likes it there.
B7. Wind power, it powers but it's a lot better than normal power stuff.
B8. Power plant, energy that you can only use once.
B9. That's a single house for only for one person there, not a giant family.
B10. It's my family home, it's a place for a bunch of families, a big giant family.
B11. That's where the other guy lives, except not lucky ducky, it isn't closer to the ground, and doesn't take that much space.
B12. That takes up a giant bunch of space, cars, street light and that.
B13. Lots of stores and that, I think that those are cars.
MARCH 28 - PARTICIPANT 3
A1. It's a forest, foxes live in forest.
A2. It a path into a forest, there's a tree that's fallen down.
A3. It's a birds nest, and it's in a pond.
A4. It's a factory with steam coming out of it.
A5. It's a garden.
A6. It's a farm, and it's fall.
A7. Those are wind, wind... wind something.
A8. It's another factory, and there's a train thing.
A9. It's a house surrounded by plants.
A10. It's a house and....
A11. Those are skyscrapers.
A12. It's winter, and that's traffic, and it's bad for the environment.
A13. It's winter, and there's a big shop with cars.
B1. That the forest where animals feel protected.
B2. It's a forest.
B3. It's pond where birds come to lay their nests, and have their young.
B4. Factory with steam coming off it.
B5. It's a garden, and that's were animals, small animals come to feed on the plants.
B6. That's a farm where people grown food.
B7. It's a wind thing.
B8. ?
B9. That's a house for one family, it's surrounded by land.
B10. That's a house that's build beside another house.
B11. That's a sky scraper that's found in a big city.
B12. It's a road, and it uses lots of space, and it's bad for the environment.
B13. It's winter, there's shops that sell toys, and clothing. and stuff.
MARCH 28 - PARTICIPANT 4
A1. Trees, grasses, a sky.
A2. I see some animals, grass sky, trees.
A3. Nest, water, different colours of sky.
A4. Farm, and all different stuff like that.
A5. Plant stuff, somewhere where people will.
A6. Farm old and rusty, and has weeds, and there's a thing behind that door.
A7. Power, wind sky, some clouds.
A8. Sky bridge, it's hard.
A9. A house, a car, the car looks like it's going to back up.
A10. A plant, a green plant, looks like way more than two people live there.
A13. Cleaning cars or something, cars.
B1. That's where the duck lives, lucky ducky, nature.
B2. Nature that's his home that's a nature and that.
B3. This is his nest that is like made out of twigs and that.
B4. Farm and that, there's a lot of smoke.
B5. That's where he can rest, and there are vegetables and that, it looks like there is a lake by it.
B6. It's a farm, a big farm there's something there, a dog house.
B7. Wind power, sky clouds, it powers stuff, but it's a lot better than normal power stuff.
B8. Power place, it's energy that you can only use once.
B9. That's a house, a single house for only one person, or a family can live there... not a giant family.
B10. That's my family house, that a house that's built for a bunch of families.
B11. That's where the other guy live, but not lucky ducky, that's where he lives and it isn't closer to the ground and it doesn't take that much space.
B12. That takes up a giant bunch of space, and there are street lights and stuff like that.
B13. That's a store, I think that those are cars.
MARCH 28 - PARTICIPANT 5
A1. It's a forest and it's really big.
A3. Birds nest, big bird, and it's a swamp, and stuff.
A4. Factory, and it's really polluting the air.
A5. It's a vegetable garden, and there's a lot of vegetables, and seeds inside it, and in front of a forest.
A6. It's looks an old farm and you can sort of tell because there is wheat growing, and other stuff that tells you it's a farm.
A7. It's somewhere on a bridge and they sky doesn't look so blue.
A8. It looks sort of like a factory, but over here the sky is really, really, blue, and it looks there a bit of a factory out of this.
A9. It's a house with really clean lawns, and the sky is really white because there probably isn't an ocean, in the background there's a car, and that causes pollution.
A10. It's looks probably like a condo, and there's a car, and the sky is blue so it's probably by an ocean.
A11. It looks like a skyscraper like the one's I've saw in Vancouver.
A12. A high-rise, being polluted by all these cars.
A13. Marks work warehouse, and Canadian tire, and tire factories, and clothes factories.
B1. Lots of trees, green, little bit of black, so the trees are dying, a white sky, means it's not by a lake, or pond, or something, it's a bush down here.
B2. Bushes, trees, trees that fell down.
B3. Ducks, nest, or a birds nest, swampy area, dead flowers, dead grass, and live grass.
B4. It's really polluting, you can tell by the smoke coming out, as it's gray, a little bit. A factory, a built thing.
B5. It's a vegetable garden, lots of animals like going there, and green stuff. There's a bit of grass here, so it's healthy, the soil quite fine, and some tomatoes growing here, a bit of trees.
B6. A bit of blue sky, it means there a lake or a river, old farm, there's a lot of space, people could possibly make a house there. Wheat in the background, there's a forest in the background, but it doesn't look too alive.
B7. In the river, they are good for the environment it doesn't really kill it that much, It looks like we're near a bridge, and then it looks like there is some fans.
B8. Another factory, except that it's turned on a little lower, and there is probably a lake, or an ocean, in the back of it, with or involved with water back there.
B9. Very green house with a lot of space so they could have moved it forward and had a bit of a bigger back yard and they could have built a playground back there. There's a car there its pollutes the earth. Especially if you run it in a garage with the door closed and there's a very white sky so that means there is probably not a lot of water.
B10. It looks like a condos for one family or ...er... probably a family of up to four people.
B11. There hotels in Vancouver, that I saw when I driving to our hotel that we are staying in. There are high rises.
B12. A highway very busy, looks really expensive, because the more cars on there it digs into the pavement, and then it goes into the gravel, it's not very good for the environment. There's a lot of gaps, and a lot of those cars.
B13. Stores that we can buy thing from, half decent stores in the world. There not so bad because people have to walk there, better than some with more cars than bike riders and walkers. There's a bit of snow there, so it probably was taken in winter, and there's a blue sky, so there is probably a lake or water near by.
MARCH 28 - PARTICIPANT 6
A1. Those are trees.
A2. Trees, cut down.
A3. Nest, in a pond.
A4. That's smoke coming from a factory.
A5. It's a garden.
A6. It's a house or a farm, a fence.
A7. ?
A9. That's a house and a black car and there's grass.
A10. A really, really, big house, and it has trees, and flowers.
A11. A building and you can get groceries.
A12. Traffic, red lights and buses, and we got stuck in traffic today.

NO POST INTERVIEW
MARCH 28 - PARTICIPANT 7
A1. Forest somewhere in the country, doesn't have any animal there.
A2. Looks kinda like a jungle, doesn't look like that much animals around.
A3. That's a beaver dam in a lake, looks like it has a rock in it.
A4. Factory with smoke coming out of it.
A5. That's a garden it looks like, got some food growing in it.
A6. That's a farm.
A7. Those are, what do you call them, they use wind, and turn them into energy.
A8. Looks like lots smoke with buildings between them.
A9. That a house with a garden in front of it, and a car beside it.
A10. That a house with a garden in front of it.
A11. Those are skyscrapers, and they're very tall.
A12. I think it's rush hour. Rush hour is when lot of cars go by, its when lots of people get work off.
A13. Canadian Tire shop, and snow, and a car shop.
B1. Forest, that's were animals sometimes have their food.
B2. That's a jungle, and with some animals there also.
B3. That's a beavers' home in a lodge, in a lake.
B4. Factory and ah it has smoke coming out of it's chimney.
B5. It's a garden, sometimes you can get lots of food from there, flowers.
B6. That's a farm, and you can grow lots of food.
B7. Those are things store energy from the wind. When the wind turns those things then it makes energy, and you need energy, you can give anything energy.
B8. It's a factory, it's a place, and it doesn't have any smoke coming out of the chimneys.
B9. That a home, and um, and it has a nice front yard, and car, and one family can live there.
B10. That a house of two families, and it looks like one cars is parked, so only one family's home.
B11. Those are skyscrapers, three of them they are very tall.
B12. That's traffic at rush hour, it has lots of cars going at rush hour.
B13. Those are shops that you can get nearly everything you need.
MARCH 28 - PARTICIPANT 8
A1. It has trees, grass, it might have animals.
A2. There are trees, and there are broke and falling trees on the ground.
A3. Nest, water river, there's a river there some grass that grown in water, there's grass that lives on land, and tall grass.
A4. There's smoke there's house er, (es) and windows.
A5. Apple, leaves, trees, birds, worms.
A6. Farm house red colour, tall grass a broken door and a hut.
A7. Little helicopters, white colour, sky.
A8. Bridge, not much grass, more brown, more smoke, more houses, blue sky.
A9. Lake, house, a fence, an chimney, and a car.
A10. Blue colour, green colour, trees, house.
A11. Beauty, red colour, lights, houses.
A12. Cars, snow, jacket, rain coat, buses, signs.
A13. Houses, cars, persons, and stores.
B1. Trees are ducks shelters, and birds' shelters, and they make their nests on it.
B2. This is where ducks live, and foxes goes in the trees, it's a fox home.
B3. This is a ducks home, and they lay there eggs here, and spend time with their friends.
B4. This is where they work, and all the store make smoke comes out of there.
B5. Ducks fly here and eat some, and take a rest and the duck goes out to get food.
B6. This is a farm where farmers grow food for us to eat at the store.
B7. This is something that makes electricity.
B8. Machine that makes something, where they do new inventions.
B9. This is a home for one family, and they don't spend a lot of time with their cousins.
B10. This is two houses connected together and they share their house.
B11. This where we live, and it doesn't take so much land.
B12. This is where the car drives, and the persons, and cars to go on.
B13. This is a store where you can buy toys, books, and video games.
MARCH 28 - PARTICIPANT 9
A1. It's a forest, it's really green, but there's not much trees, well there's trees, but not much leaves.
A2. A trail, maybe some creature.
A3. Nest, pond.
A4. Gas polluting the air.
A5. Growing vegetables, like tomatoes, and other vegetables, some cabbage maybe.
A6. I think that a farm in the fall.
A7. It's in the water, and it's the wind, and if it's strong, it will turn.
A8. In some places I see this, and I think danger, and see it makes electricity, somehow.
A9. It's a house, and it's summer time, and the grass is nice.
A10. It's a big house with cars here, and some grass, and it's summer, and has clouds.
A11. It's an apartment, and it's really high.
A12. It's the winter, it's a busy place, and traffic's really slow.
A13. Canadian tire, it's in the winter, but there's sun and cars.
B1. It's a forest full of trees, and it's a different environment.
B2. Forest and woods, and trees surrounding it.
B3. It's in the water, and there's some plants growing around a nest.
B4. It a place where stuff is created like toys.
B5. This is sorta where a farmer plants their stuff, tomatoes, vegetables, and stuff.
B6. It's a farm, I see the trees, and it's sunny.
B7. It's in the water, and these are the stuff that goes around when there are strong wind.
B8. In some places about like long time ago, some other places, and it's danger, electricity.
B9. Only one family can live in it, and it's pretty, and the grass, and their stuff, an grass, and plants surrounding the home.
B10. These can live more that one family, but that it's separate house, just that it looks together, and some bushes, and some trees.
B11. An apartment where it's really high up, the higher up, the more expensive.
B12. It snow store, and a traffic jam, the snow makes it with a traffic jam.
B13. This is where people buy stuff, and for example some buy some toys, and it's in the winter.
MARCH 28 - PARTICIPANT 10
A1. It's a forest, it has many trees, lots of leaves.
A2. Forest, a log coming down.
A3. Nest, might be a duck.
A4. Building with smoke coming out.
A5. Garden, and there's something growing on it.
A6. I think that's a farm with lots of crops out there.
A7. This is electricity, something.
A8. Some kind of tower thing.
A10. Kinda like an apartment, sort of, with car.
A11. This is a pretty tall building.
A12. Traffic on the road, and it's smelly.
A13. Canadian tire, and it's snowing.
B1. This is some animal kinda of place, and this has food.
B2. This is a where some like more animals feed them.
B3. This is where stuff like ducks and birds come since they know it's safe for them to lay their eggs.
B4. This is a factory and they make different products like barney and sell stuff like that.
B5. This is a garden to grow stuff so you don't have to buy it at the supermarket.
B6. That is farm, a big farm area for when you harvest, there's lots of food.
B7. That's where electric city stuff.
B8. This is where you make energy, you use it once, and then it's gone.
B9. One family house, with lots of nature around it, but it takes lots of room.
B10. This is like a house where two houses the are connected together for two families.
B11. This is a big apartment, it has many floors.
B12. Traffic light, there's lots of polluting, and gas coming out.
B13. This is where you buy your food, and supplies that you need.
MARCH 28 - PARTICIPANT 11
A1. It's outdoors and it's in the forest, it's like camping, and like when people go exploring.
A2. Going exploring in the forest.
A3. A bird's nest, that a bird lays a nest in the pond.
A4. It's smoke, factory, it's bad for the environment.
A5. A farm, there's lots of fruit and vegetables.
A6. A barn with, um, grass that needs to be cut.
A7. Fan that generates electricity.
A8. ?
A9. It's a house, and roof, is getting repaired or something ....
A10. A house that's double.
A11. A skyscraper, and I think that it's in Vancouver or something.
A12. It's traffic, or maybe there's a traffic jam, or something.
A13. Canadian Tire, and it's really snowing out, and they have to drive slowly.
B1. The home for lucky ducky, it's a forest, trees.
B2. It's, um, a forest exploring nature, and trying to find an animal.
B3. Lucky ducky pond, and it has a nest with his son or daughter.
B4. It's bad for the environment it's a factory where lots of things get made.
B5. It's a farm with lots of vegetables, and foods, and it's very healthy for the environment.
B6. It's good for the environment, but same as the other one, but it has wheat to make healthy bread.
B7. A clean way to make electricity.
B8. A dirtier way to make electricity.
B9. That's a home for one family, a car parked.
B10. That's a house for two families, but it's also one house.
B11. A man, and it's a skyscraper, and it lives very tall, but it has everything he needs.
B12. Those are roads, but we need them, and they are very expensive.
B13. Those are stores where you can buy video games, and fruits, and vegetables, and all the healthy things you need.
MARCH 29 - PARTICIPANT 12
A1. Tree, straight has leaves on in, in the shade.
A2. Jungle, bushes, leaves logs, leaves sticking out. I've been there after school.
A3. Ducks nest, used to be eggs in there, and it's in the water.
A4. Building, it's has really much, really smoke coming out of it, I'm allergic to smoke.
A5. It looks a patch for tomatoes, I see bushes, and it kinda looks like a little maze.
A6. It looks like a farm, it has wheat it has a tree, it has these tall bushes in a line.
A7. It has these kinda like huge windmills, and they going around, and around, and they have these tall poles holding them up, and it's on the ground and it's largely sized.
A8. It's kinda looks like giant poles, and I'm not quite sure what it looks like.
A9. That's a house it's taken green there's a car beside it.
A10. That's a really long house, it has a blue car, some bushes, trees, it's painted brown.
A11. That kinda looks like that hotel right here, it's kinda looks like my cousins, and it is my cousins, woo, It's three hotels in the picture and there's a lamp post there and a door.
A12. That's a lot of traffic, it's buses and traffic and cars there's the light that show what time to go, a lady holding an umbrella over her head.
A13. It looks like a super market it has window, doors.
B1. Grass, trees, the sky.
B2. Well there's lots of bushes, trees, logs, dirt, there's a little dark spot near the corner.
B3. There's lots of weeds around and water, that's all I know.
B4. Well there's lot of smoke, it's a little place, it has sky, it's really gray.
B5. It has a nice blue sky it has trees, bushes, grass.
B6. It's kinda like a farm it has a red shed windows weeds, it's brown it has trees it has bushes.
B7. Its has lots of windmills, there's lots I can't count them there's grass and a whole lot of sky.
B8. This is like electricity that you can only use once, and you get these poles over here, and these thing that go around it.
B9. That's a house it's green, it has a big car beside it, grass, gravel another house, trees, sky.
B10. It's really long, it has a blue car, and it's painted brown, trees, red and green bushes, green grass, stairs.
B11. There's a hotel, some of side is red blue, the other one is painted blue, there's a light.
B12. It's traffic, it's really hard to get through.
B13. It's a supermarket, it has parts, it has a blue recycling bin.
MARCH 29 - PARTICIPANT 13
A1. That's a tree, it has chlorophyll in it. It can grow up to be really, really big, like the one in my yard.
A2. It looks like a rain forest, with lots of animals, birds, and insects live in the trees.
A3. That's a beaver dam, I think, and beavers use their teeth to chew sticks, and piles them to make their home.
A4. That's a factory, and it's polluting with all the bad thing that are coming out with steam.
A5. A garden, and usually has lots of flowers and vegetation in it.
A6. A farm usually has cows or a big crop in it.
A7. I think those provide electricity.
A8. I'm not really sure what this is.
A9. People live in houses, and it provides shelter for them.
A10. That looks like a double house, usually two families live in it, but usually have one big kitchen, and share the house.
A11. Skyscraper, usually hotels or businesses, that have lots of offices in them.
A12. Cars are always polluting the air from all the steam that come out from behind them, and their gas.
A13. That's a supermarket where people buy food.
B1. Animals live there and they depend on it for shelter.
B2. Foxes and animals goes there, that's where they find food, water.
B3. Wetlands are where things like to swim.
B4. Those are polluting.
B5. Community gardens provide food for humans as well as animals.
B6. Farmland they also make food for humans as well as animals.
B7. Those create energy and we can reuse it.
B8. That all where we make energy but once we use it it's gone forever.
B9. Single family take up more space, they take up lots of space.
B10. Those homes are squished together, but there actually two separate homes, they have room for a playground or something in the backyard, and it takes up less space.
B11. Those are offices where people need to work, so they can get paid, and food and everything they need.
B12. Road are expensive to make, and they take up lots of space.
B13. That's where we buy food, and toys, and other stuff that we need.
MARCH 29 - PARTICIPANT 14
A1. It is a tree, not an evergreen.
A2. It's a forest, and there's lot of wild animal there.
A3. It's a beaver dam, and it's made out of twigs, and branches.
A4. It's a factory, there's a lot of smoke.
A5. It's a garden, and there's lot of plants.
A6. It's a barn, and there's weeds.
A7. It's up in the mountains, and they make air.
A8. ?
A9. It's a house, and it has a very nice lawn.
A10. It's another house and it has a lot of blooms.
A11. It's a skyscraper, and skyscrapers are very big.
A12. It's a street, and there's lot of cars.
A13. I think it's a bank, and it keeps money, and grows money.
B1. These are trees, and there homes for the birds.
B2. These are forest, and this is where animals play.
B3. These are the beavers, and there's made out of bark.
B4. There factories, and they store up on electricity.
B5. These are gardens where we grow food, and eat.
B6. These are barns, and they grow thing.
B7. These store electricity from the sun.
B8. These store electricity too.
B9. These are houses, and where people live.
B10. These are town home that different families share.
B11. These are tall buildings that are called sky scrappers.
B12. These are streets and how we travel.
B13. These are stores where we get groceries, video games.
MARCH 29 - PARTICIPANT 15
A1. Animals live in the trees, it's a forest, and some other animals live there.
A2. That's where squirrels, birds, mostly plants live.
A3. That's where ducks live, and they sleep, animals look for food.
A4. That's a factory, sometimes it pollutes some plants near it, sometimes pollutes the plants.
A5. It's a farm, and it grows vegetables, and fruit.
A6. That's a barn, and it holds animals, like cows, and stuff, horses.
A7. Those are used for a company that make electricity, they use wind to make electricity.
A8. That's where the electricity gets brought to, that's about for the people who turn on the TV's and stuff.
A9. That's a house where somebody live, a pet lives, or something.
A10. That's a townhouse, one family lives on one side, and another family lives on together.
A11. Those are skycrapers, they are buildings that are very tall, and they scrape the sky that's why they are called skycrapers.
A12. It is traffic, and cars, and they call it rush hour.
A13. That is for places where you can buy video games, toys, food and all that stuff.
B1. It's where some animals live, like squirrels, and chipmunks, if there's water around it.
B2. There's squirrels rhinos, tigers, mostly plants, and all that stuff.
B3. That's where their ducks live, and if the mother goes out for food, they tag along and that's where they eat.
B4. That's factories for making stuff, and if you don't have anywhere to sell it, that's why you need some malls or something.
B5. That's a garden or a farm, that's where ducks live, and have stuff to eat, sometimes, and birds.
B6. That's where animals stay for a while.
B7. It's a clean way of making electricity, it's eco friendly.
B8. That's where they send out electricity, like last time I said.
B9. That's a house where a family lives, or a pet, or a dog or something, it's theirs shelter.
B10. That's a townhouse where two families, or three, it has a couple walls, and one family lives in each house, and it's like one big house put together.
B11. That's a sky scraper, it scraper that scrapes the sky, and that's where some people live.
B12. That's traffic, it costs more money, cause they have to repair it and all that stuff.
B13. That's where you buy video games, toys, foods, groceries, and all that stuff.
MARCH 29 - PARTICIPANT 16
A1. This is trees, and there's grass.
A2. It's a forest, there's plants and trees.
A3. It's a river.
A4. There's smoke.
A5. A garden, they have vegetables.
A6. That's a barn, there's some weeds.
A7. Windmill.
A8. Long things.
A9. House, there's a flag, and a car.
A10. That's a house, it's a bigger house, there's two people live in there.
A11. They're skyscrapers and buildings.
A12. There's cars, and it's snowing, and it's stuck traffic.
A13. A mall or something.
B1. Trees, birds can make nests in them.
B2. That's a forest, ducks can live in the trees.
B3. That's a bird's nest, and this is a lake, the bird lives in the nest.
B4. That's a factory, it has lots of smoke.
B5. That's a garden, there's lots of food.
B6. That's a barn, and there a place to grow food and stuff to eat.
B7. Those are windmills.
B8. That's a place to make electricity.
B10. That's a house where a lot of people live in it.
B11. That a city, they are skyscrapers and living, and malls.
B12. That's are streets.
B13. That's a shopping, where people can buy stuff.
MARCH 29 - PARTICIPANT 17
A1. It's a tree, and it's very large, as you go under it is very shady it looks like a forest there are many trees.
A2. It's a beaver's dam, they use branches to make it.
A3. It's smokes, it's kinda polluting the air.
A4. It's a planting field, it's very green.
A5. It's a farm, farmers live there, and work.
A6. It's a wind turbine, they make electricity.
A7. This is something like smoke stack.
A8. ?
A9. It's a house and people live in it.
A10. It's a townhouse a lot of people live in there.
A11. They're apartments and more than 3 people can live in it.
A12. It's a street with many cars and it looks like a traffic jam.
A13. It looks like something where you buy something.
B1. It's a bird's nest, and they feel protected, and safe here.
B2. Trees, birds like to play here.
B3. Birds can meet there then play there.
B4. People make toys, candies, and other things here.
B5. People get food from here.
B6. Farmers can get many food for people to eat.
B7. That is for generating electricity.
B8. They also make toys and stuff here.
B9. Only one family can live here, and it takes up a lot of space.
B10. One side, this house can live it's for two families, and they can share space for playground.
B11. Many people can live in these high buildings, and it's very easy to go to malls and other places.
B12. A lot of people drive cars on it, and many people use it to go to work.
B13. Everyone buys candies, and foods from here.
MARCH 29 - PARTICIPANT 18
A1. That looks like a tree, it's summer.
A2. It's a forest and it has lots of details, the trees are a little cracky.
A3. It's that a beaver dam, it looks like a big nest.
A4. There's smoke all over, I think it's during the middle of the day.
A5. It's a garden, and it has a lot of detail, and it's really pretty, and I love gardening.
A6. It's like a farm, there's thingies here.
A7. I know that there in a row.
A8. It's detailed, an maybe someone works there.
A9. It's a house, there's a big garden, and there's a flag on top.
A10. It looks like an apartment, and it has a beautiful background, and there's a car.
A11. There big buildings, and there very tall.
A12. Buses and cars, and white, and red.
A13. It's a store.
B1. It's summer, and the leaves are green, and there's no snow flakes, and there's a big field.
B2. It's a forest and the trees are cracky and it has lots of detail.
B3. It's a bird nest, I mean duck nest, and it's floating on top of the water.
B4. There's smoke everywhere and they make things.
B5. It's a garden and there's lots of things growing.
B6. It's a farm and there's lots of weeds all over, and there's trees too.
B7. Windmills in a line.
B8. It looks odd, and maybe there's somebody working in there.
B9. This is a house, and it's only for one family, and there's a flat on top of it, and a garden, and a car.
B10. This is a middle apartment, and there's lots of families, not only one family, It's good, it's nice to see other people.
B11. The buildings are very high, and the red thing looks odd.
B12. Traffic and there's car a bus and people walking there.
B13. It's a store where you can buy toys and food, anything.
MARCH 29 - PARTICIPANT 19
A1. It's a tree, and it's summer time, it kinda looks like it's spring, or it's summer time.
A2. That it's a forest, and it looks like there's lots of logs.
A3. It's a beaver dam. I'm sure that a beaver lives in it.
A4. It looks like a factory.
A5. It's a garden, people plant stuff, and there are tomatoes there.
A6. It's a farm, and I think that they are growing wheat over there.
A7. Giant windmills.
A8. Some sort of electric garden.
A9. It's a house with a car on the side.
A10. It's a house, I don't know if someone painted it.
A11. Three towers, and I think that they're in the city.
A12. It's winter time, and lots of cars are driving around.
A13. That store looks like IKEA.
B1. It's a tree, there's leaves on it, and it looks like it's spring, or summer.
B2. There's lots of logs, and leaves, and animals.
B3. I think probably two or one beaver is in there.
B4. I think it's a factory, and there's lots of smoke.
B5. I see tomatoes growing over here, and there's lots of leaves, and stuff, and also vegetables, and flowers.
B6. I think that they are growing some food over here, and there's a farm over there.
B7. There exporting more air over to the land.
B8. It's electricity.
B9. It's a little car parked beside the house, and evergreen trees.
B10. I think someone painted that.
B11. There lots of cars, and it's in a city, and those are tall towers.
B12. It's winter time, and all sorts of cars are driving on. Some are driving up and some are driving down, to get to other places.
B13. It kinda looks like IKEA. There's lots of blue, yellow and red.
MARCH 29 - PARTICIPANT 20

A1. Tree, provide oxygen.
A2. Tree, humongous trees.
A4. There's a bunch of smoke coming from that.
A5. Its a crop, I see tomatoes.
A6. It's a house, and a home.
A7. ?
A9. House, and a car.
A10. There's a car, a house with two doors.
A11. Three big buildings there.
A12. A bunch of cars.
A13. Looks like a store, and you can buy stuff there.
B1. There are two trees, they provide oxygen, there's grass.
B2. It's a jungle, they have lots of trees.
B3. It's a birds nest floating in water.
B4. It's a place where things are made, paints, and stuff like that.
B5. It's a crop and it's growing tomatoes.
B6. It's a barn they have chickens in them.
B7. Those things provide energy, the energy's is used to light, light bulbs.
B8. There's a whole bunch of building, and a whole bunch of poles.
B9. That's a house for one family, and it takes up a lot of room.
B10. That's a house that has room for more than one family.
B11. There are three building, and they are tall.
B12. There a bunch of car on the street, they build streets.
B13. It's a store and you buy stuff.
MARCH 29 - PARTICIPANT 21
A1. Tree, sky, clouds, trees need water.
A2. That's like a camping spot, and that someone's been there.
A3. It's a birds nest, and they have eggs in it.
A4. It's like a factory, that they make stuff.
A5. It's a garden that they plant stuff and make fruits.
A6. It's a farm, they produce fruits and vegetables.
A7. That things is for producing electricity.
A8. It's electricity thing.
A9. It's a house and people live there.
A10. It's a townhouse, two houses in one.
A11. Giant building and there's lots of houses in there.
A12. It's traffic, that's a road that cars go on.
A13. It's a mall and people buy stuff there.
B1. It's a tree and that's the shelter of animals, and the sky.
B2. It's a land where people and animals live and a ....
B3. This is a home for ducks and birds and there's food there.
B4. It's a factory where people make toys and stuff for people.
B5. It's a garden where birds fly around and eat stuff.
B6. There's a barn, people live there and sometimes animals go there.
B7. I forgot the name again, and it makes electricity and it goes around in circles.
B8. That makes electricity, and you can only use it once, and when you use it, it's gone.
B9. It's a house where people live, they have a big garden.
B10. It's one house, where two families live in, and it has a shared garden on the street.
B11. It's a building that doesn't take up as much space, and a lot of people live in it.
B12. It's a road that's expensive to make and it takes a lot of money to fix.
B13. It's a place where people buy stuff.
MARCH 29 - PARTICIPANT 22
A1. Tree, trees grow apples in the summer. When spring time trees grown blossoms.
A2. That is a forest and some people go into the forest and bears live in the forest.
A3. This is a beavers home, beavers chew on trees and trees break and he puts sticks on his house.
A4. This is a sky and skies are blue and have clouds too.
A5. This is a garden and gardens grow tomatoes salad and flowers.
A6. This is a barn and barns have many animals and owls and barn owls eat mouse so the mouse don't eat lettuce.
A7. This is an ocean and oceans have boats on it and many boats have people in it.
A8. ?
A9. This is a house and lot of people have house (s) and many stuff and have cars parked inside or outside.
A10. Same as the other ones a long house.
A11. A lot of people in lot of families some people live in small houses some people live in big houses.
A12. These are a lot of cars. And cars drive to many places, and Alaska.
A13. These are a store and a lot of people goes to stores to buy things.
B1. This is a trees, and I got good ideas, and birds live in trees, and sunshine give trees the birds food and water too.
B2. This is a forest, and many people goes to the forest, and goes deeper and bears kinda would chase them.
B3. This is a beaver dam, and beavers swim to finds sticks to build their house.
B4. This is the sky, and sky, sky helps....
B5. This is a garden, people grow stuff in it like flowers, food.
B6. This is a farm, a lot of farmers live in a farm, and many chickens too.
B7. This is the sky and sky helps and I kinda don't know.
B8. ?
B9. This is a house, and one family lives in this house.
B10. This is a house, and somebody, the builders, built another house right beside. It's good because neighbors.
B11. This is a house for a lot of people to live in. You have to spend money and then you can live in one of these house.
B12. This is a road and it takes a long time to build it, and then cars, after it's build, cars drive on it.
B13. This is a store and a lot of people go there to buy things, like books, and toys and bo-- and flowers.
MARCH 29 - PARTICIPANT 23

A2. Forest.
A4. Factory, they make a lot of pollution. It's scary how much.
A5. Garden, they have fruits and vegetables, flowers
A6. Wheat field, it's a farm.
A7. ?
A8. ?
A10. A house with three houses in it.
A11. A huge city. I think they are skyscrapers.
A12. Traffic jam.
A13. Some kind of store, department store.
B1. It's two trees, a sunny day.
B2. It's a forest I love hiking in them. There are usually full of trees and plants if there not they are generally not a forest.
B3. It's a birds nest and it looks like it is in a marsh. It's a duck cause it's in a marsh.
B4. Factory and it causes a lot of pollution.
B5. It's a garden with apples. Some can be full of flowers some can be full of edible fruit.
B6. It's a farm and a barn. They usually keep animals in the barn.
B7. ?
B8. Maybe another factory.
B10. I can't remember what it's called. But it's a house with three houses in it.
B11. It's a city with a bunch of buildings.
B12. It's a traffic jam and I thinks it's near my school and house.
B13. Department store.
MARCH 29 - PARTICIPANT 24

A1. This a picture on the prairie. Oak tree and there's a spruce or a pine tree in the background and it looks like it's summer. Trees give us oxygen, they can be made into paper, wood, and all the stuff that you would find mostly in your house.

A2. That looks like a forest, somewhere maybe in BC I've seen something like that. They contain a wide variety of trees and plants and animals.

A3. That is a beaver dam. It looks like it is at a lake or a pond. And the beaver stations it close to a food source, plants and looks like it's spring.

A4. This looks like a big industrious factory where there are toxic fumes are coming out that are destroying the ozone layer in the sky making global warming and because of that there is cold air going through.

A5. This is a orchard growing various fruits and I think I see apples or something on the vines could be grapes or limes and I think there is a pond or a house in the background.

A6. We are looking at something in Saskatchewan. there is a barn with a red paint and the rest is more brown. There's some wheat, wild wheat or something. The ground is very good for growing plants. Farms that can be made into bread or cereal.

A7. That it is a wind farm. The wind goes and hits the propeller which moves them and makes electricity. There's a generator and it makes electricity.

A8. That a power plant. There's lots of them around the world and that's where the raw energy goes and it's transferred into a safe energy that is sent along the telephone poles to your house.


A10. That is in the suburbs that is a townhouse. And there is a blue car parked in the front.

A11. Those are some very tall building where there are some offices where very important people work like lawyers and they are in there doing paperwork. And their really tall buildings again.

A12. This is in the winter. It is a traffic jam, probably in rush hour and it is west 16 ave. And there's a pole bus and another pole bus and lots of vans and cars. That they are usually caused when people in a usual time when people are off work and have to pick up kids.

A13. I think it's a recreational place or school. I can see there is lots of traffic lights and it's got lots and lots of windows.

B1. These are trees animals can hide in them live in nooks and crannies holes they cans support in trees the ducks and this is a spring or summer picture and that's an oak and that a pine or spruce tree.

B2. That's a forest there's lots of animals there's lots of prey lot of predators for other animals and a various amount of trees.

B3. That is a swamp. Wetland or it can be a lake it is a beaver dam it is placed by lots of spreading food that can be used once it is needed.

B4. That is an industry where they make lots of things toxic fumes and the things they could make could be chocolates, could be cars it could be anything that could be manufactured.

B5. That is a community garden. Well it's a good place to grow food and lots of nice plants that you can feed a whole community and you can pitch in and garden and it's food.

B6. This is a barn, a farm. This is your old farmhouse and that is your barn with, with wood that is reddish brown and part of it a warm red. It is pretty strange looking at red. Beside it is a trimmed wheat field with some wheat still standing up in the background and way up front. Most of it's gone.

B7. That is a bunch of wind turbines. They are using a natural force to make electricity which is very efficient.

B8. That is non renewable electricity source plant. Also that is where they generate the electricity.

B9. That is a single family home and it has a blue car in the background it's got a nice lime green with white trim Canadian flag a little chimney and looks like a cool neighborhood in the summer.

B10. That is a condo. Condos are houses that can hold multiple families.

B11. Those are giant building they could be apartments office building for lawyer peoples and at the base you can see little entrance place.

B12. That is a road a, traffic hour, er at a traffic jam. It's rush hour there's a full bus and followed by it is a full bus and lots of cars.

B13. That is a store, a Canadian tire and there you can get all the stuff you need like food and games.
MARCH 29 - PARTICIPANT 25
A1. It's a picture of two trees ones big and ones small. Trees are the source of H2O I know H2O stands for oxygen.
A2. That picture is of a forest. Forests have lots of trees and has oxygen.
A3. That is a birds nest. Birds nest are where all the birds lay their eggs.
A4. This is a factory that is polluting the air with it's gases.
A5. It's a vegetable garden. They grow vegetables in it.
A6. There's a barn leaves, and there's a forest around it. Barns keep the warm animals.
A7. Those are power windmills that means they generate power from the wind.
A8.?
A9. It's a family residence. That they have a car.
A10. That is a looks like a kinda apartment.
A11. Those are skyscraper apartments. There's like 10 houses on every story.
A12. That is a road. Roads cause lots of pollution cause of all the cars driving on it.
A13. That's a store. That's where you buy stuff.
B1. These are trees that are home to the wildlife.
B2. That is forest which is home to lots of wildlife or animals and also the perfect place to take your dog for hiking.
B3. It is a wetland where lots of fish swim and birds make their homes.
B4. It's an industry building where they build stuff. But they are also very polluted.
B5. This is a community garden where people grow stuff that can grow in the garden.
B6. That a farm, where farmer grown food and have animals at their farm.
B7. This is a windmill and they make power from the wind.
B8. That is non-renewable energy where they get the power to use this voice recorder.
B9. This is a one family home but it can also have a tenant and a suite.
B10. That is a house and that is an apartment or a three person home.
B11. That is an apartment or condos which is where lots of people live.
B12. That is roads where vehicles travel and it also cause pollution.
B13. That is a shopping centre like an area where you go to buy your food.
MARCH 29 - PARTICIPANT 26
A1. It's a tree that they are green and sometimes we chop them down because they get too big.
A2. That's a forest and more people are cutting them down to make parking lots, malls.
A3. That is a dam. Beavers build them to block up the water and to have a home.
A4. That's a factory of some sort and it is giving off a lot of smoke.
A5. That's a garden and people use them to grow things or flowers to look at.
A6. That's a farm and it is used for storing animals and the fields are for cropping.
A7. Those are something I forgot the name of and they are used for energy. And they are very big.
A8. It's a above water on a lake and it's for water treatment. and if it is that is where they clean all the water and send it back through the pipes.
A9. That's a house and people live in it.
A10. That's another house and might be....
A11. That is some building in the city and they are used mostly for working.
A12. That is cars and a driveway and that is where cars drive.
A13. That is a car company and sells cars.
B1. That's a tree it is there and sometimes there in forests and sometimes they are just rumbling around everywhere.
B2. That's a forest. That bird told me that it's a place to roam and they are sometimes can be torn down.
B3. That is a beaver damn and they are for beavers and they have little home in them and they can block the water.
B4. That is a, where they make things.
B5. That is a community garden that is where people who live around it can come and plant and get fresh vegetables and fruits.
B6. That's a farm where animals get stored in the winter and the good for the environment or something.
B7. Those are meant for energy or something and they can also be very, very, very large.
B8. That is a factory and it can, things are made in there.
B9. That is a single family house and it can only fit one family.
B10. That is a multi family house and it can fit more than one family.
B11. That is that dude's house and it is very high and doesn't take up a lot of room.
B12. That is a driveway and it is meant for cars to drive on.
B13. That's a Canadian tire and you can buy thing like toys, videos games, food.
MARCH 29 - PARTICIPANT 27
A1. It is a tree, they help clean air so we have oxygen.
A2. It's a forest and lots of animals live in it.
A3. It is water it looks like a beaver dam. They use it to protect themselves.
A4. That's pollution it a factory and they make stuff in it.
A5. That a garden and that's where they grow fruits and vegetables.
A6. That's a barn where people keep animals.
A7. Those help not use electricity.
A8. Looks like something that ....?
A9. That's like a house and yah where people live.
A10. That's an apartment that's also where people live.
A11. Those are building that are getting built.
A12. That's a lot of traffic!
A13. Those are stores where people shop.
B1. That's a tree. It's good for the environment.
B2. That's a forest. That's where animals live.
B3. That's a swamp a that's where fish and ducks can swim.
B4. Non-renewable energy it pollute the nature.
B5. That a garden and it's a good for your friends and family around you to eat.
B6. That's a farm and that's where animals live.
B7. That's renewable energy and since it's renewable it doesn't really pollute the air.
B8. That's a factory where our food and toys are made.
B9. It's a house where people live. It take up space.
B10. That a place where families can live and it doesn't take up as much space.
B11. That's another place where you live and it takes up less space.
B12. That's a road and it's really expensive to fix. It takes up space.
B13. That's a shop where we buy our food.
MARCH 29 - PARTICIPANT 28
A1. It's a trees it's roots suck water.
A2. That's a forest with lots of animal, some of them are being cut down.
A3. I think it's a beaver dam. Not a house I don't know what it's called it's home.
A4. That's a factory, it's kinda bad cause they pollute a lot.
A5. That's like a garden. Kinda It looks like it could be on a farm or something. And it can grow tomatoes and lettuce.
A6. That's a farm and there's green and trees.
A7. ?
A8. The kinda look like electrical.
A9. That's a house, there's lots of them.
A10. That's like kinda like a duplex what I live in. But looks like there's probably more behind it like where my aunt lives.
A11. That's a skyscrapers. There really big and some of them are work buildings.
A12. Cars, also big polluters and there are buses their too.
A13. It looks like something like Wal-Mart but not Wal-Mart I can't see anything on it. And they are kinda bad for the economy.
B1. It's a home for a lot of animals not one tree but many trees. And we need lots of them to build houses and have lots of air to breathe.
B2. There's lots of trees and more animals live it in sometimes different kinds.
B3. Wetlands are good for bird and beavers.
B4. It's like a factory and it pollutes a lot and it's where objects are made.
B5. That's like a community garden it's where we get fruits and vegetables and foods we buy from the store.
B6. That's a farm it's kinda like a community garden but usually not as close and there's more grains.
B7. That's reusable energy and it's better for our planet than non-renewable.
B8. That's non-reusable and when we're done we kinda give it away and it's bad for us.
B9. That's a house, not really as a good as townhouse or a skyscraper cus it's pretty big and only one family can live in it.
B10. That's a town house about three houses put together but it's not as big.
B11. That's a skyscraper or like an office building. It's small but its a right amount of space.
B12. That's a road with cars and stuff and we need roads to get places with vehicles.
B13. Those are stores and you need the right amount of store to have things like homes and cars and food.
MARCH 29 - PARTICIPANT 29
A1. That's a tree and animals live in it.
A2. It's a forest and animals can also live in a forest.
A3. That's a pond and fish live in ponds.
A4. That's a factory and it pollutes the air.
A5. It's a garden that can feed people.
A6. It's a farm and it has barn animals in it.
A7. It's for energy,
A8. ?
A9. It's a house that's where people live.
A10. It's also a house people also live in it.
A11. It's an apartment building people live and work in it.
A12. It's traffic and the cars pollute the air.
A13. It's a shop where people get their food.
B1. It's animals home. And it's where birds live.
B2. That where animals and people can go in.
B3. That's a home in the water for a duck.
B4. That's where they make toys and candy and stuff.
B5. That's where they grow food and sometimes animals get in it. A garden.
B6. That a farm and its' where animals live and people get their food.
B7. That helps get electricity.
B8. That is a factory and they make electricity there.
B9. That's a home for a family and it takes up a lot of space.
B10. That's it's sorta like a house only smaller and attached to one another.
B11. That's where people live they live up high sometimes.
B12. That's a road and that's where cars go on and it cost a lot of money.
B13. That's where you buy toys and food and stuff like that.
MARCH 29 - PARTICIPANT 30
A1. Trees, grass trees are good they make paper.
A2. Those are more trees and plants.
A3. It looks like a giant nest, there's water around it, a swampy area.
A4. It's pollution. Bad for the air not good for the human life.
A5. Garden, it's good and people like to eat most of the thing in the garden.
A6. It's an old barn, or maybe they just made it look old but kinda looks like it's fall.
A7. It's they are all windmills.
A8. Not really good for everything find wasteful.
A9. House, looks like it's in Canada and people live in those and their good but not all people have them.
A10. That's a two person house and it's split in half and two families can live in them.
A11. That looks like some building probably people work in them.
A12. Those are cars vans buses its pollutes our air and it would be better if people just to walking and riding bikes and maybe not all of them need to own a car and can take the bus more.
A13. A building, I don't really know what building but a building,
B1. Trees and they are good for our planet and they protect things, the more trees the better.
B2. It's a forest and it's good and it protects some animals and gives lots of shade.
B3. That is swampy waters and it good for some animals.
B4. That is very bad for the planet it pollutes our planet a lot. It's called a factory.
B5. It's a garden. It can be good but it can be bad when people use a certain stuff on them to grow bigger. So that's bad.
B6. That's a farm and you don't need too many of them it's good to have some cows, pigs and you can get eggs and all that stuff.
B7. Those are windmills and they clean the air.
B8. That's another factory it wastes energy and it's not that good and you can't use it over.
B9. It's a home and it's not always good to have and you could probably fit you and you could probably put two homes on that property and park up the street so more people could live in that space.
B10. That's better but it's two homes together and no kinda but and it good for the space and it's pretty good.
B11. Those are apartment blocks and those are very good and cause lots of people can live in them and they go up high and don't take up as much space.
B12. Those are cars and buses and they pollute our air and it's not good and it would be better if people just rode bikes and just walked more.
B13. And that is a shopping mall and it can be good and it can also be bad sometime it gives ups tools to buy thing and it can give us clothes and water and food but it can also can be a waste since you don't need it all sometimes.
Comment: It made me think about things a little more. I liked planning out how the world could be a better place.
MARCH 29 - PARTICIPANT 31
A1. Tree, they give you oxygen.
A2. Forest, animals live in them.
A3. Nest in water, maybe goose or duck or frogs live in them.
A4. Factory, they make stuff.
A5. A garden you grow stuff.
A6. A farm, that's where you grow stuff and keep animals.
A7. Windmills. They mill wind.
A8. Milk machines, they grow milk.
A9. That's a house people live in houses.
A10. People live in those apartments.
A11. People work in buildings; people work in them.
A12. Traffic, traffic's slow.
A13. Mall, and you can buy stuff in malls.
B1. A tree and birds live in it.
B2. A forest and bird like to go into the water and swim.
B3. A birds nest a lake and the guy like to go with his friends into their and eat bugs.
B4. Factory where candy, comic and books are made they make other stuff.
B5. Gardens birds like to go into gardens and go into the birdbath and take a rest.
B6. Farming, that's where they grow food and animals.
B7. Those make electricity.
B8. Also make electricity.
B9. People live in them and they have lots of land.
B10. One house is a house for people and there's another house beside it for people.
B11. People live in apartments.
## APPENDIX F - GRADING SHEET RESULTS BASED ON THE TOWARDS UTOPIA RUBRIC

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