A sound idea: An investigation into accessible video game design for the deaf and hard of hearing

Luke James Brook

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A sound idea: An investigation into accessible video game design for the deaf and hard of hearing

This thesis is presented for the degree of

Doctor of Philosophy

Luke James Brook

Edith Cowan University
School of Science
2017
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helped to maintain my sanity and kept me grounded. Cooper, I dedicate the doctorate to you. You are an inspiration, and it is because of you this research was ever conceived.
Abstract

A widely accepted, and incorrect, assumption towards hearing accessibility in video games is that deaf and hard of hearing (DHH) users are those who encounter the least barriers and are generally well catered for. Rapid advancement in video game technology has seen video game sound evolve from simple blips generated by internal circuitry to fully realised digital audio used to convey critical information. To accommodate the DHH, this information needs to be conveyed in an alternative manner. However, evidence suggests existing accessible design solutions for the DHH lack specificity and are insufficient. Thus, the inability to hear, or hear well, has historically resulted in DHH users left with impeded experience and gameplay.

This thesis describes an investigation to address the primary research question: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing? To examine this question, an action research method as part of a transformative mixed-methods methodology was used. Data collection procedures included critical analysis of literature, observations, and a cross-sectional self-administered survey for triangulation.

The critical analysis of literature exposed issues relating to accessible video game design, particularly in relation to the identification of solutions and technical implementation. Further, issues related to the classification of video game software were identified. This posed potential problems with identification of game design methods and led to the development of a new video game classification model. The new model informed an analysis on the methods used for the design of video games, and results were visually represented and mapped to the different approaches to accessible design. Subsequent analysis determined that a game assessment framework is a suitable approach to facilitating accessible design.
Further investigation identified visual feedback as the most suitable form of complementary feedback to game audio. This led to the development of a new model to classify visual feedback elements used in video games, and identification of audio feedback categories based on diegetic film theory. Through triangulation of results, a new game feedback model (GFM) was developed.

The GFM was used for observational experimentation to identify and classify individual visual feedback elements used in video games. Each element was analysed and mapped to categories of game sound. The resulting model, with populated data, was used to determine what visual feedback elements may be used to complement specific categories of critical game audio. A survey was subsequently used for triangulation, and resulted in amendments to the final model.

Through iterative development, and interpretation of findings, the research culminated in the development of a game assessment framework. The three-step framework aids in the classification of game sounds; assesses the impact of those game sounds; and provides recommendations for complementary visual feedback elements for sounds identified as having an adverse impact on user experience and gameplay if they were to be removed. The framework is innovative and has the potential to provide practical guidance for developers of video games. In addition, this research provides the foundation for future research, with the potential to influence accessible game design for the DHH.
Chapter 1: Introduction and Background

1.1. Overview of chapter

This thesis investigates and identifies the current limitations in accessible video game design for the deaf and hard of hearing (DHH). Further, it explores and determines a potential solution to aid in the development of accessible video games. This research builds on findings from a previous study conducted by the researcher, which investigated the potential of a video game designed for the screening of hearing loss in children. The study was recognised nationally for its innovation and contribution to industry, receiving two industry awards. The aim of the video game was to aid in addressing the growing public health concern of otitis media (OM), a common middle ear disease, in Australian children (Brook, 2013).

Results of the previous study indicated that current video game design guidelines and development frameworks provide limited guidance for developers when designing video games for children who are DHH (Brook, 2013). Such limitations include guidelines for the design and implementation of an appropriate user interface and selection of game design elements, per the age and developmental capabilities of the user. It was determined that these limitations have an adverse impact on a user's experience and engagement, influencing the effectiveness of video game based early interventions for health and education.

Consequently, to develop a means of facilitating accessible video game design for the DHH, the research questions for this study focused on:

- The identification of current video game design practices, which might include general design and specific aspects;
• Approaches to accessible design for the DHH; and
• An investigation into video game sound typologies and visual user interface elements

This chapter introduces the background and significance of the research, statement of research questions, scope of the research, and outline of the thesis.

1.2. Background to the research

Hearing loss has become a critical health concern. It is considered the most widespread sensory deficit and frequently occurring birth defect in the world. According to the World Health Organization, more than 360 million people worldwide are affected by some form of hearing loss (Störbeck, 2012; Traynor, 2011; World Health Organization, 2017). From a global perspective, the percentage of individuals affected by hearing loss in developing countries is as extensive as in developed countries. Developing nations consist of approximately 80% of the global population, resulting in a higher number of affected individuals in the developing world overall (Traynor, 2011; Tucci, Merson, & Wilson, 2010).

Hearing loss can occur at any age as the result of several different factors, and can be either congenital or acquired (World Health Organization, 2017). The leading cause of acquired hearing loss in children, globally, is attributed to a common middle ear disease, otitis media (OM), where fluid solidifies and impedes conduction of sound through the middle ear (Burrow & Thompson, 2006; World Health Organization, 2017).

According to Peta Monley, Chief Executive Officer of Telethon Speech & Hearing, this form of hearing loss is acquired after birth. In addition, it is typically not detected during routine hearing screenings, such as the newborn hearing screening. Thus, a large percentage of children remain undiagnosed (P. Monley, personal communication, May 1, 2014).
The exact cause of OM is frequently disputed, and some believe OM to be an unavoidable occurrence in all children (Weber, 2012; Yiengprugsawan, Hogan, & Strazdins, 2013). However, the consensus is that early intervention is a key solution and, once detected, the disease can be managed via appropriate medical or surgical interventions (World Health Organization, 2017). If left untreated, OM can result in the more severe chronic suppuratives otitis media (CSOM), where fluid can rupture the ear drum, further limiting the conduction of sound, or can result in permanent hearing loss (Burrow & Thompson, 2006). Without early intervention, a hearing loss is proven to have an ongoing functional, social and emotional, and economic impact in a child’s life through to adulthood. The inability to hear, or hear well, may cause a delay in receptive and expressive communication skills; cause social isolation and poor self-concept; result in poor performance in classrooms or the inability to learn. (O’Keefe, 2012; Timms, Grauaug, & Williams, 2012; World Health Organization, 2017). Additionally, in developing countries, “children with hearing loss and deafness rarely receive any schooling” (“Economic impact”, para. 1) and “have a much higher rate of unemployment once they reach adulthood” (World Health Organization, 2017, para. 16).

In Australia, the number of children with a hearing loss is comparable to third world countries. In addition, Aboriginal and Torres Strait Islander children in remote, and extremely remote, communities have “prevalence rates … much higher than among non-Indigenous children and well above World Health Organization thresholds” (AIHW, 2014a, p. 5). Community-based epidemiology studies have found cases where more than 90 percent of Indigenous children, between the ages of zero and five, had been diagnosed with OM (Morris et al., 2005; MSHR, 2013). In Australia’s Northern Territory, health services have reported cases where more than 72 percent of Indigenous children have presented with middle ear infections, and over half of those diagnosed with some form of symptomatic hearing loss (AIHW, 2014). In addition, Bensink et al. (2010) state that a large percentage of children, who
suffer from hearing loss, have not been diagnosed due to lack of immediate and regular access to health care professionals to seek diagnosis and treatment.

In response to the high incidence of middle ear disease, hearing impairment, and the resulting developmental delay, several telehealth solutions have been trialled. Telehealth can be defined as the “use of telecommunication techniques for the purpose of providing telemedicine, medical education, and health education over a distance” (“Telehealth,” n.d., para. 1). These primarily consist of mobile clinics, which have shown promising results, although several constraints were identified (Bensink et al., 2010; Healy, 2008; O'Keefe, 2012). Carol Jacobs, Assistant District Director for the Department for Child Protection and Family Support (CPFS), believes that these constraints have an adverse impact on the effectiveness of these approaches. Australian geography is vast and traversal by land vehicles is time consuming, and often hindered by issues such as seasonal flooding; and restricted access to outsiders in Aboriginal communities due to customary lore (C. Jacobs, personal communication, 2013; O'Keefe, 2012). In developing countries, issues relating to access to medical care is more of a concern, with the ratio of health care professionals to people between 1: 500,000 to 1:6.25 million. While paraprofessionals are being utilised to aid in the screening of hearing loss and general ear health, recommendations suggest utilising telehealth solutions where an on-site audiologist is not available (Störbeck, 2012).

As a potential solution, a study was conducted as part of an Honours project by the researcher. The study investigated the potential of a low cost, easily distributable video game software application, designed for mobile and tablet devices, to aid in the screening and diagnosis of hearing loss in children. The developed software aimed to overcome the above-mentioned constraints, with hearing screening conducted locally on a tablet computer or mobile phone, and results from assessments sent
electronically to health professionals for review (Brook, 2013). The twelve-month project resulted in the development of a serious game, which may be defined as “software that merges a non-entertaining purpose (serious) with a video game structure (game)” (Djaouti, Alvarez, & Jessel, 2011, p. 2). The game was developed in accordance to existing video game accessibility guidelines ("Game Accessibility Guidelines," n.d.; "Making Video Games Accessible: Business Justifications and Design Considerations," 2013), and based on the DODDEL model serious games design framework (McMahon, 2009). Subsequent testing, and collection of data, was conducted to determine the accuracy and feasibility of the serious game (Brook, 2013). The results of the study determined the application could produce accurate results in comparison to a traditional audiogram, which is a standardised method of measuring hearing ability in a controlled environment. Qualitative data analysis determined that health care professionals, parents, and children were comfortable using the technology; and the study provided proof of concept supporting future research and development of similar health and education applications. Potential future applications include serious games to aid in early intervention strategies, such as speech and occupational therapy, to address the symptomatic developmental and learning delay often experienced by DHH children (Brook, 2013; Störbeck, 2012). However, certain limitations were identified during the previous study. These included appropriateness of the game design, per the age and developmental capabilities of the child participating. It was determined that these limitations had an adverse impact on the user’s experience, engagement, and accuracy of the testing process. Further investigation determined these issues stemmed back to the inadequacy of existing accessibility guidelines and non-prescriptive developmental frameworks for accessible game design for the DHH.

Numerous developmental frameworks currently exist (Adamo-Villani, 2006; Adamo-Villani & Wright, 2007; Amory, 2007; de Freitas & Jarvis, 2006; Djaouti et al., 2011; McMahon, 2009; Tang &
Hanneghan, 2010); yet they lack specificity for hearing accessibility design, or design considerations specific for children. Existing accessibility guidelines ("The AbleGamers Foundation," 2014; "Game Accessibility Guidelines," n.d.; Park & Kim, 2013) provide extensive guidance for cognitive, visual, and physical/motor impairment, with limited information for hearing loss.

Frequently cited hearing accessibility considerations include the use of closed captions or subtitles; yet they lack consideration for the target audience’s age, ability, ethnicity or locale. As mentioned previously, children with a hearing loss often experience developmental delay, which extends to a delay in reading proficiency. This negates the effectiveness of subtitles and closed captioning as a sole accessibility consideration for young children (American Speech Language and Hearing Association, 2004; Dickenson, 2014; Khairi Md Daud, Noor, Rahman, Sidek, & Mohamad, 2010; Tucci et al., 2010). This perspective, on the inadequacy of accessibility guidelines and design frameworks, has been anecdotally observed and reaffirmed by the researcher, through their role as a lecturer and tutor in Games and Interactivity at Edith Cowan University. The role involves providing instruction to novice student designers on the topic of game design. Novice student designers, and those unfamiliar with game development, often require additional guidance during the design process (McMahon, 2009). Students, whom the researcher taught, often cited difficulties with accessible design during game design assessments. This was due to lack of standardised industry guidelines and insufficient level of detail with existing published resources.

Further, while it may be argued that expert and seasoned game developers can circumvent such accessible design problems by drawing on prior experience, such as abstract knowledge and recollection of practical experiences; current video games provide contrary evidence. A preponderance of published video games have been found to lack appropriate accessibility considerations, or have
minimalistic implementation, providing an insufficient level of accessibility. This is advocated by the existence of numerous community groups, predominantly on the world wide web, which serve to bring awareness to the claim that “deaf and hard of hearing gamers [are] mostly ignored by the gaming publishers” (Claridge, n.d., para. 3). These community groups are responsible for:

- retrofitting published video games to increase hearing accessibility by adding suitable game mechanics through modifications (Mods) ("About Games(CC]," n.d.; BrushBaron, 2006; Sacheverell, 2015); and
- …for the petition for amendments to video games, and game services, to make them accessible to the DHH (Kirk, 2013; Krissy, 2013).

The lack of appropriate implementation is not due to a lack of awareness amongst the game development community. Informal interviews conducted by AbleGamers (2009) indicated that approximately 69% of video game developers had considered how disabled people play games they developed. On conclusion of the interviews, the authors posed the question “with so many who have heard of the issue, why is it still an issue?” This is perhaps due to lack of knowledge toward implementation within the industry as one interviewee stated, they “have thought about it … [but] didn’t really come up with any solutions”. Furthermore, discussions with seasoned developers, who are considered to have successfully implemented hearing accessibility in their games, discussed how they have taken a non-standardised approach to accessible design (M. Laidlaw, personal communication, 2015; Y. Bernier, personal communication, 2016). These developers also share the belief that additional work in the area is required (R. Kimball, personal communication, 2015).
The issue of inaccessibility has also been fuelled by the fact that video game software has been excluded, or not explicitly identified in equal rights and anti-discrimination laws or legislation. This has resulted in failed lawsuits against video game publishers and developers who have failed to accommodate people with a disability (Powers, Nguyen, & Frieden, 2015). In some countries, this issue is being publically addressed. Government organisations, such as the United States Federal Communications Commission (FCC), are in the process of amending regulations to mandate video game software being “accessible to and usable by individuals with disabilities” ("FCC Extends ACS Waiver for video game software," 2015, p. 10017). However, these regulations are only inclusive of internet based player-to-player communication, excluding other elements of accessible video game design.

Delays to immediate implementation of amended laws and legislation provide further evidence for the need for new approaches to accessible game design. The previously mentioned FCC amendment was to be implemented by 2015 and has been successfully delayed on appeal until January 2017 by the Entertainment Software Association (ESA) ("FCC Extends ACS Waiver for video game software," 2015). The appeal was accepted on the basis that “the gaming industry has not been able to benefit from and utilize the experience gained in making ACS [advanced communications services] accessible in other contexts”, such as web and video. In addition, it is believed that “[v]ideo games present dramatic technical challenges and a unique – and difficult – environment in which to deliver accessibility solutions” ("FCC Extends ACS Waiver for video game software," 2015, p. 10022).

This thesis recognises that existing approaches to accessible video game design for the DHH are currently insufficient. This research aimed to extend on the understanding of accessible game design
for the DHH by studying existing approaches; identifying potential alternative approaches; and presenting an alternative means of developing inclusive video games for the DHH.

1.3. Research questions

The primary research question addresses the problems identified for accessible game design for the deaf and hard of hearing (DHH); and the need for the exploration of accessibility solutions. Review of literature, related to the design of games for the DHH (see 2.8), and a preliminary investigation into the development of accessible video games (see 2.9), provided the primary research question:

Research Question 1: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?

Preliminary investigation (see 2.10) also concluded that additional research was essential to develop a better understanding of what was required to support the primary research question. This included literature related to video game medium, game design methods, and accessible game design. These findings formed the following sub-questions:

Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?

Sub Research Question 1.2: What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?
1.4. Aims of the research

Based on the issues identified for accessible video game design for the DHH, introduced in section 1.2, and the research questions outlined in section 1.3, the aims for this research included:

- Development of a potential solution to aid in design of accessible video games for the DHH;
- Classification of existing game design methods, game design frameworks, and current industry game accessibility guidelines to develop a better understanding of approaches to game design; and
- Identification and classification of the audio-visual feedback elements used in video games, and interrelationships between these elements, to develop understanding and bring attention the significance and impact of each form of feedback.

1.5. Significance of this research

The intention of this research was to identify a means of improving video game accessibility for the deaf and hard of hearing (DHH); and utilise these findings to amend the hearing screening video game developed during the previous study. Inaccessibility was identified as a limitation of the serious game developed in a previous study by this researcher. Increased accessibility could potentially increase user engagement, resulting in improved accuracy and reliability of hearing screening using the application; and facilitate the diagnosis of hearing loss and middle ear disease in children where game design is used as part of the diagnosis testing. In turn, earlier diagnosis would lead to intervention sooner.

It is well established that children with a hearing impairment “who begin early intervention earlier have significantly better developmental outcomes than similar children who begin early intervention later” (Bradham, Caraway, Moog, Houston, & Rosenthal, 2009, p. 1). However, less than 10 percent of children, who are DHH, have immediate access to required early intervention. Serious games
developed for early diagnosis and early intervention may provide a real solution. The potential benefits for a serious game to be used for diagnosis as noted above are in addition to the benefits for the use of serious games for education, which are varied and known to include:

- safe and cost-effective mechanisms;
- increased and maintained attention;
- accommodation for multiple learning styles;
- the ability to teach and expand on concepts; and
- increased retention of knowledge (Girard, Ecalle, & Magnan, 2013; Guillén-Nieto & Aleson-Carbonell, 2012; Li & Tsai, 2013; Papastergiou, 2009; "Solving the training dilemma with game-based learning," n.d.; Young et al., 2012)

However accessible design considerations first need to be addressed. Few attempts to develop games for diagnosis and early intervention for DHH exist, or have limited functionality (Adamo-Villani, 2006; Adamo-Villani & Wright, 2007; Brook & Williams, 2013; Eden & Passig, 2000; Kearney, 2005; "What is Sound Scouts?," n.d.). This is often attributed to limitations in design, specifically in the areas of non-audio reliant feedback and visual interface design (Adamo-Villani, 2006; Eden & Passig, 2000). Increased knowledge around accessible game design could potentially aid video game developers in creating more suitable games for the DHH. In turn, this may increase user engagement, aid in early diagnosis and intervention, and potentially reduce the impact a hearing loss has on a child’s overall learning and development.

Additional benefits include a reduction in cost and development time for serious games for DHH children. Previous solutions for hearing accessibility have focused on the use of virtual reality, which requires fixed, costly and/or cumbersome hardware (Adamo-Villani & Wright, 2007; Eden & Passig,
The provision of alternative approaches to accessible serious game design software, without the reliance on specific hardware, would facilitate the development of serious games for common consumer devices and off-the-shelf portable consumer hardware. This would potentially reduce the cost of equipment for users; decrease development cost and time for video game developers; and increase ease of distribution for video game publishers.

In addition, the significance of this research extends beyond the initial scope, as the design of video games for diagnosis of hearing difficulties in children is a subset of the larger issue of design of video game software for the DHH. The findings of this research have the potential to promote change not only in video games for education and health, but across the entire video game spectrum; and the potential to influence the more traditional video game industry. Existing guidelines and developmental models used in the design of serious games, for education and health, are often the same as those used in developing games for purely entertainment purposes. Thus, the issue of inaccessible game design extends beyond the scope of this research and is inclusive of mainstream video games for entertainment purposes. The original contribution to knowledge this study provides may potentially result in both novice and expert designers being able to successfully develop suitably accessible games, for the DHH, across the entire video game spectrum. In turn, this may also aid in establishing new standards for equal rights and anti-discrimination laws and legislation.

Amendments to existing equal rights and anti-discrimination laws and legislation have been postponed, due to insufficient knowledge in accessible video game design ("FCC Extends ACS Waiver for video game software," 2015). According to the WHO, “human rights legislation and other protections can … help ensure better inclusion for people with a hearing loss” (WHO, 2015, "Identification and management", para. 5). However, without additional exploration into potential
accessibility solutions, further appeals may be submitted resulting in additional extensions to waivers, and potentially further games released without appropriate accessibility considerations.

Without this study, game designers may continue to develop video games for the DHH with a limited toolset, continued reliance on expensive or impractical hardware choices, restricted accessibility options or poor design choices. In relation to the issue of hearing loss at large, the lack of understanding for accessible video game design for the DHH may result in the continued development of unsuitable serious games. In turn, this may result in an ongoing and unanswered need for telehealth solutions. If left unresolved, the number of children with an undiagnosed hearing loss may continue to increase, in addition to limited access to early intervention. This may continue to lead to prolonged adverse impact for a child who is DHH, including impeded psychosocial and educational progress, lack of employment opportunities in adulthood, and overall degradation to their quality of life.

1.6. Out of scope of the research

This section describes factors related to video games and video game design which were out of scope of the research.

Impact of Screen Based Media Use

As identified in the literature review, the impact of prolonged exposure to screen-based media is claimed to have an adverse impact on the participant, including health issues, as well as providing a platform for illicit or risky behaviour ("Media and Children," n.d.). However, this topic is still an area of contention, with no evidence to support or refute the claims, and further investigation is required (Houghton et al., 2015; Yang et al., 2013). It is important to note that this research does not claim to investigate the issue, and was considered out of scope for this research.
**Impact of explicit content in video games**

The impact of violence and explicit content in video games on children is under continuous debate, and numerous studies continue to produce conflicting results (Anderson et al., 2010; Azar, 2010; Ferguson, 2015; Freedman, 2002; Gentile & Bushman, 2012; Gentile et al., 2014). Furthermore, some believe the impact may never be known, due to broad intra-personal and environmental factors, making it difficult to isolate video games as a primary contributor (Lee & Vessey, 2000).

The issue of the impact of explicit content in video games is beyond the scope of this study. It is assumed that content, considered unsuitable for children, will be omitted by developers when designing video games for children. In addition, games which contain such material are expected be classified as inappropriate for young audiences by media classifications organisations. An example includes Australian Classification, which provides age appropriate ratings for video games in accordance to the *Classification (Publications, Films and Computer Games) Act 1995* (2015).

**Hardware based feedback**

Hardware based feedback, including virtual reality, haptic and tactile feedback, is often referred to in accessibility guidelines and academic studies as an alternative form of feedback for the DHH. However, preliminary investigation determined that such approaches are dependent on the target platform, limiting the potential application. Inclusion of hardware based feedback had potential to impact the generalisability of the potential solution for this research.

As a result, this research did not investigate the use of hardware based feedback. Instead, the scope of the research was refined to accessible video game software design with a focus on audio-visual
feedback. This choice was also in-line with findings from critical analysis of literature, which identified visual forms of feedback as an optimal form of alternative feedback for hearing accessibility.

**Testing of accessibility solution**

This research aimed to identify a means of facilitating accessible video game design for the DHH. This was achieved by exploring and providing foundation knowledge for various topic areas, including:

- identification of approaches to video game design, and relationships between the approaches;
- classification of visual and audio feedback elements and identification or relationships between those elements; and
- using the results to identify a potential means of facilitating accessible design in the form of a game assessment framework.

While the lack of testing for the game assessment framework in a real-world environment may bring question to its validity, the findings are considered the result of this research, and the original contribution to knowledge. The potential solution provides a foundation for future research.

**1.7. Thesis structure**

The conventional doctoral thesis is typically structured as a linear progression, with definitive chapters such as the literature review, research methods and design, data collection procedures, and discussion of results. It is important to note that this thesis does not strictly adhere to such as structure, due to the action research method used. As a characteristic of action research, the direction of the research was responsive and informed by continuous learning and reflection. To ensure comprehensiveness, this thesis has been structured to provide an accurate representation of the iterative research process encapsulated in the action research method.
For example, an explicit description of the data collection and analysis methods employed in a study might typically be contained to a research design chapter. However, as this research employed a Look, Think and Act cyclic research method, the explicit details of all cycles of data collection and analysis were initially unknown. As a result, the initial design of the research is described in detail in the Research Design chapter in addition to generalised processes for qualitative and quantitative data collection and analysis. Subsequent additions, such as a survey and anecdotal observations of video games, are described during the planning (Act) stage of the respective cycles to accurately reflect the iterative research process.

Interpretation of data and discussion of results might typically appear in a discussion and conclusion chapter. However, in this research the interpretation and analysis of data in each action research cycle informed the next cycle. As a result, the interpretation and discussion for each cycle is included in each Act stage to demonstrate the logical flow of the research.

In addition, critical analysis of literature may typically be contained within a single chapter. However, in this thesis a critical analysis of literature occurs in Chapter 2, informing the research problem. Due to the exploratory nature of action research, additional analysis of literature also appears in Chapter 4: Analysis of game design methods, and in Chapter 5: Analysis of sound topologies and visual feedback in video games.

The credibility of a literature review is also often judged based on the account of quality publications related to the field. It is important to note published literature related to the field of video game accessibility and video game design is sparse. The video game industry is historically non-academic (see chapter 2.6), and unpublished sources such as web-content, blogs, and product pages are often
the only sources documenting developments in those fields. This is discussed in further detail in the literature review (chapter 2.7-2.9) and in the research cycles (chapter 4 and 5).

This thesis is organised into seven chapters:

**Chapter One: Introduction and Background**
This chapter introduced the research, including the background and significance, research questions, aims and approach.

**Chapter Two: Literature Review**
The literature review chapter consists of:

- an overview of the current state of hearing loss and impact of hearing loss on a child’s development and learning.

- an overview of children’s screen based media use
  - a discussion on the increasing availability of electronic media and children’s screen-based media use in both home and schooling environments; and
  - analysis on the impact of video games on health and wellbeing.

- a discussion on the design of video games for the DHH, including the previous study and findings which led to this research.

- an introduction to the video game medium, including a brief history of video game hardware and software.

- an analysis of the videogame sub-genres of serious games, virtual worlds, and simulations. This section includes identification of issues regarding definition and classification, and presents a new classification model.

- an analysis on game design methods:
  - Instructional design models
Game assessment frameworks
- Generalizable game design approaches
- Targeted game design approaches
- Predictive and adaptive approaches

- an analysis on accessible video game design approaches.
- formation of research questions based on findings of the literature review

Chapter 3: Research design
Introduces the theoretical framework and chosen action research methodology. This chapter describes the research approach used to determine how video games might be better designed to accommodate the DHH. The chapter also includes discussion on research participants, ethical considerations and limitations of the study.

Chapters 4-6
Each chapter describes a cycle of the action research method, including the data collection, review, and analysis. Due to the nature of the action research method, discussion and results are included on completion of each chapter (cycle).

- **Chapter 4: Cycle 1 – Analysis of game design methods**
  - This chapter provides an analysis on the game design methods from the literature review, identifies the relationships between those methods, and presents findings in diagrammatic format. Findings are used to determine a method to facilitate accessible design for the different game design methods.

- **Chapter 5: Cycle 2 – Analysis of sound topologies and visual feedback in video games**
  - The chapter is presented in three sections:
    - an investigation into game sound typologies (iteration 1);
    - an investigation and video game mechanics (Iteration 2); and
• the development of a populated video game feedback model, to identify the relationships between visual and auditory feedback in video games (Iteration 3).

• Chapter 6: Cycle 3 – game assessment framework for hearing accessibility
  
  o This chapter is presented in three sections:
    ▪ First attempt at developing a game assessment framework (Iteration 1)
    ▪ Second attempt at developing a game assessment framework (Iteration 2)
    ▪ Third attempt at developing a game assessment framework, with several example scenarios to guide implementation (Iteration 3)

**Chapter 7: Conclusion**

Summarises this research and discusses the benefits and potential implications. Further, the chapter includes suggestions for future research in accessible video game design for the DHH, and the proposed game assessment framework.
Chapter 2: Literature Review

2.1 Overview of chapter

Chapter 1 provided the background to this research, which included an overview of hearing loss in children and accessible video game design for the deaf and hard of hearing (DHH). This chapter expands on those topics, and provides support for the chosen research questions introduced in Chapter 1. The principle areas of this chapter include:

- **Impact of hearing loss and its continuum**
  Provides an analysis of the current state and impact of hearing loss. This includes a discussion on the types and causes; and issues related to diagnosis and treatment.

- **Developmental delay and learning difficulties**
  Identifies issues related to a child’s development and learning because of hearing loss, and the importance of early intervention.

- **Children’s screen based media use**
  Discusses trends in availability, and children’s use of, electronic screen-based media. The purpose of this section is to determine how screen-based media may be utilised as a method of delivery for serious game based telehealth and tele-education solutions to aid in diagnosis and treatment of hearing impairment in children.

- **Design of video games for the DHH**
  Introduces previous research, which has informed and influenced this research.

- **History of the video game medium**
This section introduces the video game medium. Included is a brief history, and discussion on the evolution of the underlying hardware and software. This also includes an overview of game audio, and the evolving role of audio in video games.

- **Serious games, virtual worlds, and simulations**

Serious games, a sub-genre of video games, is introduced. This section includes an investigation into the issues related to classification and identification of serious games.

- **Game design methods**

This section provides an analysis on the approaches to video game design. This includes a review on the methods employed in both commercial environments and by independent developers. Reviewed and identified game design approaches include:

  - instructional design models;
  - game assessment frameworks;
  - game design frameworks;
  - generalisable and targeted approaches; and
  - predictive and adaptive approaches.

- **Accessibility in video games**

Investigates the current state of video game accessibility in academia, the industry, and the wider community. This includes:

  - an introduction to accessibility in game design;
  - a review of hearing accessibility guidelines for video games; and
  - approaches to accessible game design for the DHH in academia.

- **Formation of research questions**

The research questions developed based on findings in the literature review.
2.2 Impact of hearing loss and its continuum

Hearing loss can occur at any age, and is considered the most prevalent sensory deficit in the world. According to the World Health Organization (WHO), approximately 360 million people, or 4.8% of the global population experience disabling hearing loss (Traynor, 2011; WHO, 2015; World Health Organization, 2017). Of those, approximately 32 million are children aged below 15 years, and 7.5 million aged below 5 years (WHO, 2015). The Global Burden of Disease Hearing Loss Expert Group provides a greater estimate of 538 million people, or 7.4% of the global population aged 5 years and older having a disabling hearing impairment (Bolajoko, Katrin, & Saunders, 2014). Regardless of the classification, the incidence of hearing impairment exceeds WHO thresholds, and it is considered a major public health concern. The causes of hearing loss can be the result of several different influencing factors, including congenital or acquired causes.

Congenital hearing loss, which is a hearing loss present at, or soon after, birth affects approximately 6 in every 1000 births in the developing world and 2 in every 1000 births in developed countries. It is recognised as one of the most common birth defects globally. Congenital anomalies may include, but are not limited to, consanguineous marriage, infections during pregnancy, low birth weight, or severe jaundice in the neonatal period (Traynor, 2011).

Acquired causes refer to external influences after birth resulting in either conductive and/or sensorineural hearing loss. The degree of hearing loss, as a result of conductive impairment, varies as the individual’s perceived loudness of sound is reduced “by blockage or damage in the outer ear, middle ear or both” ("Types of hearing loss," 2013, para. 2). Some of the causes include infectious diseases, injury or excessive noise. The leading cause of acquired temporary and permanent hearing loss in children is attributed to otitis media (World Health Organization, 2017).
Otitis media (OM) is a general terminology for inflammation of the middle ear. OM describes commonly occurring viral and bacterial middle ear infections, where fluid solidifies and impedes conduction of sound. It can be mild to moderate, intermittent or persistent (Burrow & Thompson, 2006). Left untreated OM “may become chronic, increasing the risk of permanent hearing loss” (p. 10), and it is also cited as the primary cause of symptoms including fever and ear pain (Burrow & Thompson, 2006; World Health Organization, 2017). The extent of the disease is so vast that it was reported more than five million cases of OM were diagnosed each year in the United States, and it is the primary reason of prescription antibiotics in children (Hendley, 2002). However, some health professionals consider the impact of the middle ear disease, in Australia, to be the most severe of any developed country.

During an interview with ABC Premium News in 2012, Professor Harvey Coats, a paediatric ENT surgeon who has spent 35 years travelling to remote areas of Australia treating otitis media, stated that Australia has the worst middle ear disease of any first world country (O'Keefe, 2012). Further evidence to this claim was provided in a 2013 study conducted by the National Centre for Epidemiology and Population Health. The study presented data showing more than half of all Australian children experience at least one episode of otitis media by the age of 3 years (Yiengprugsawan et al., 2013).

In addition, the study determined OM occurs more frequently, and with higher severity, in Australian Indigenous children (Yiengprugsawan et al., 2013). A similar claim was made by Professor Coats, who stated most of the people he has treated have been Aboriginal children (O'Keefe, 2012). Industry experts have also stated an estimated 40 percent of Aboriginal and Torres Strait Islander children in remote communities and other rural areas, between the ages of 0 and 14, are affected by some form of hearing loss (P. Monley, personal communication, May 1, 2014; Burrow & Thompson, 2006).
However, while many experts agree about the current state of ear infection in public health, there are conflicting opinions on the exact cause.

In 2006, an article published in the Aboriginal and Islander Health Journal, titled *Summary of Indigenous health: Ear disease and hearing loss*, noted that the poor condition of Indigenous children’s ear health, especially in remote communities, was due to environmental and living conditions. This included overcrowding, poor hygiene, and housing (Burrow & Thompson, 2006). Similarly, former CEO of Telethon Speech and Hearing, Paul Higginbotham, indicated that, “where some of the conditions are poorer and people don’t have […] good housing and reliable nutrition” (para. 10) the occurrence of OM can escalate as high as 90 percent (Weber, 2012).

Conversely, some believe OM to be an unavoidable and common occurrence in all children. OM is thought to be symptomatic of an infection, such as the influenza virus, where bacteria and/or virus spread via fluid to the middle ear. This can result in build-up of fluid and inflammation of the middle ear (Weber, 2012; Yiengprugsawan et al., 2013).

Unfortunately, the inability to determine the exact cause of middle ear disease has made it increasingly difficult to establish effective preventative measures. Trials conducted to prevent the disease with vaccines targeted towards the initial infection, such as influenza, have been ineffective (Hendley, 2002; Weber, 2012; Yiengprugsawan et al., 2013). The consensus of reviewed literature is that early intervention is key, and the disease can be dealt with via appropriate medical or surgical interventions after it has been detected (Burrow & Thompson, 2006; O'Keefe, 2012; Weber, 2012; World Health Organization, 2017; Yiengprugsawan et al., 2013).
Not all forms of hearing loss can be resolved via medical or surgical intervention, as “there is rarely any medical treatment for sensorineural hearing loss” ("Types of hearing loss," 2013, para. 3). Sensorineural hearing loss is the “result of damage to, or a malfunction of, the cochlea (the sensory part) or the hearing nerve (the neural part)” (para. 3), and may be acquired or congenital ("Types of hearing loss," 2013). Regardless of the type, hearing loss is considered to have a significant adverse impact on a child’s development, including psychosocial and educational progress if left undiagnosed and without early intervention.

2.3 Developmental delay and learning difficulties

There is unanimous agreement of all literature reviewed that a child’s growth and development occurs rapidly throughout childhood (American Speech Language and Hearing Association, 2004; Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Khairi Md Daud et al., 2010; Garhart, 2013). Between infancy and 5 years of age, development proceeds “at a pace exceeding that of any subsequent stage of life” (p. 4), and is thought to be heavily influenced by a child’s environment and experiences. However, “development in the early years is both highly robust and highly vulnerable”, with a heavy influence on the “larger scheme of lifelong development” (National Research Council and Institute of Medicine, 2000, p. 4).

This was demonstrated in the Abecedarian Project, a 21-year longitudinal study, that investigated the impact of educational early intervention on a child’s cognitive and academic development. Participating children received intervention in the form of educational childcare, between the ages of 0 and 5, with follow-up academic test results collected at regular intervals until the age of 21. Results determined that children, who received early intervention, attained higher levels of achievement in academia and in cognitive testing. The study concluded that early educational intervention can have a positive impact on a child’s development through adulthood (Campbell et al., 2001).
In relation to the impact of hearing loss on education, a study conducted in 2010 at the University of Science in Malaysia (USM) was conducted to determine whether there was a correlation between hearing loss and academic performance. The study determined that there was a high incidence of mild to moderate hearing loss in children who attended primary school. Those same children were also found to generally perform poorly academically. The authors concluded that hearing impairment is significantly associated with poor academic performance, and has an adverse impact on a child’s interaction with their environment (Khairi Md Daud et al., 2010).

In 2004, researchers from Vanderbilt University presented similar findings at the American Speech-Language-Hearing Association convention. Their study provided conclusive evidence that an undiagnosed, unilateral, and moderate to mild hearing loss resulted in a child being ten times more likely to suffer academic difficulties than their peers. One third of children having to repeat a school year, or requiring additional assistance at school (American Speech Language and Hearing Association, 2004).

Moderate to mild hearing loss, which is the most common result of OM, often remains undetected. A child with this type of hearing loss is generally able to hear many sounds in their environment, but may be unable to hear soft sounds or sounds within a certain frequency. Further, these children often experience high levels of stress and fatigue due to additional mental or cognitive effort expended to listen and process information; and they are often “believed to be ignoring or not paying attention since they appear to hear with no apparent difficulties” (American Speech Language and Hearing Association, 2004, para. 3).
This is not the full extent of difficulties a child with a hearing loss may experience. Left undiagnosed and without intervention, hearing impairment can also have an adverse impact on communication skills. In turn, this can lead to feelings of loneliness, isolation and frustration (Tucci et al., 2010). In later life, this can also result in a higher chance of unemployment (O'Keefe, 2012; Timms et al., 2012; World Health Organization, 2017).

From this review, it stands to reason that, for children who suffer from a hearing loss, early detection and intervention may vastly improve their quality of life. This is because children “who commence intervention earlier have significantly better developmental outcomes than children who begin early intervention later” (Bradham et al., 2009, "Facts on Hearing Loss in Children", para. 3). However, additional solutions for the diagnosis of hearing loss and the availability of early intervention practices, including rehabilitation, need to be addressed. It is proposed that video games specifically developed for education and health may be a potential solution. This potential solution is possible given the increase in children’s screen-based media use (SBMU) and availability of electronic media devices.

2.4 Children’s screen-based media use

Children born between the early 1980’s and until present day are generally considered to be a generation of digital natives. Digital natives are those who have been exposed to a digital world from a young age with multiple forms of information, entertainment and social communication available electronically, anywhere and anytime (Skiba & Barton, 2006). Additionally, where books, board games and other forms of play were once at the forefront of a child’s leisure time, this has drastically changed.

Recent studies have shown that children’s consumption of digital media, including using computers, portable electronic devices, and playing video games, has become “the most common leisure activity of youth in Australia and many other industrialised countries” (p. 3). The consumption of digital media
“accounts for the highest proportion of sedentary activity amongst children and adolescents” (Martin, 2011, p. 4). The increase in screen based media use (SBMU), supports the researcher’s stance on utilising video games for education and health applications. The increase in SBMU, and availability of technology, provides an easily accessible platform for deployment in both home and school.

In the United States, children’s electronic media use is rapidly increasing. The number of children who use mobile devices has almost doubled, with an increase from 38 percent in 2011 to 72 percent in 2013. This includes children under two years of age, with 38 percent having used a mobile device up from 10 percent in 2011 (Common Sense Media, 2013).

In 2015, Common Sense Media released a report with data related to digital media consumption by young people in the United States. Results showed that daily digital media use by children aged 8 to 12 averaged six hours, and nine hours for teenagers aged 13 to 18 years. On average, daily media use for the 8-12 age group included 1 hour and 19 minutes playing video games, while the 13-18 age group a comparable 1 hour and 21 minutes (Common Sense Media, 2015).

The most recent statistics in Australia showed similar growth, with 90 percent of children, aged 5 to 14, having accessed the internet via a home computer or mobile device, an increase from 65 percent in 2006 ("Children’s participation in cultural and leisure activities, Australia," 2013). The percentage is expected to rise further, with the Australian Government funded Digital Education Revolution (DER), where laptops were provided to all public high school students between 2012 and 2013 (Barrett, 2013). Schools were “able to purchase a mix of devices, including netbooks, laptops, tablet computing devices and desktop computers … [and] supporting infrastructure, such as in-classroom, wireless networking” (Arthur, 2013, para. 4).
While the federally funded program has been discontinued, many Australian public primary and secondary schools have continued to integrate the technology “into all curriculum areas to enhance teaching and learning” ("1:1 Laptop Program," 2016, para. 4). In Western Australia, students at selected primary and high schools are required to purchase their own laptop or tablet device for use in their studies at school and at home ("1:1 Laptop Program," 2016; "1:1 Macbook Program," n.d.; "iPad Program," n.d.; "One-to-One Program," 2016; Smith, 2014).

In relation to video game SBMU, a recent study conducted at the University of Western Australia (UWA) investigated children’s daily usage of forms of screen based digital media. Data collection included various activities, such as video games, social networking, email, school work and television viewing. Results of the study determined SBMU was found to increase with age. However, primary school children were found to be more likely to play video games, for more than two hours daily, than adolescents. Conclusions of the study determined “there is a clear international evidence base which indicates that young people’s ... [usage] exceeds the < 2 hours recommendation” (Houghton et al., 2015, p. 2).

The maximum two hour SBMU guideline was first introduced in 2001 by the American Academy of Pediatrics in response to concerns regarding children’s excessive media consumption. The recommendation was supported by studies claiming, “excessive media use can lead to attention problems, school difficulties, sleep and eating disorders, and obesity”, and “can provide platforms for illicit and risky behaviours” ("Media and Children," n.d.).

However, the UWA study suggested that current recommendations to restrict SBMU “may no longer be tenable” given that “parents and children are enthusiastically embracing the digital age” (p. 9) and
the rapid increase in school derived SBMU. Further, recommendations are made for additional research to “develop evidence based SBMU guidelines for children and adolescents in relation to the mental, social and physical health impact of such behaviours” (p. 9), and to “take cognizance of the extent to which screen use differs across form, activity, sex, and age” (Houghton et al., 2015, p. 10). The recommendation for evidence based SBMU guidelines is likely in response to the fact that current research is conflicting. Both positive and negative outcomes in children have been reported, and the relationship between SBMU and well-being remains unexplained. This is a position supported by Yang, Helgason, Sigfusdottir, and Kristjansson (2013), who have stated that “the causality of increasing exposure to screen media, health risk behaviours and other correlated problems among children is continuously under debate, but much remains to be understood in this regard” (p. 492).

In addition to the SBMU guidelines, it is worth noting that parental acceptance of video games in childhood health and education is considered crucial. This is because, “teachers, students and policy makers appear to be influenced by what parents think” (Bourgonjon, Valcke, Soetaert, de Wever, & Schellens, 2011, p. 1434). However, on further investigation, it was discovered that data regarding parental recognition and acceptance, for utilising video games as a medium to do more than simply entertain, is sparse and conflicting.

An Australian publication titled Digital Australia, which is a bi-annual study conducted in collaboration with Bond University and the Interactive Entertainment Association of Australia (IEAA), reported that:

- 73 percent of parents said games helped their children learn about technology;
- 68 percent said games help their children learn maths; and
• 64 percent said games helped their children learn to plan (Brand, 2007, cited in McMahon & Ojeda, 2008).

While these statistics are relatively dated, more recent statistics regarding parental acceptance are not available as the publication reports findings on different key areas with each iteration. The most recent publication, from 2016, reported:

• 98 percent of homes with children have video games;
• 90 percent of gaming parents played video games frequently with their children;
• 35 percent of children used video games as part of their school curriculum (Brand & Todhunter, 2016).

Further evidence is provided in the study, conducted by Houghton et al. (2015). The study investigated SBMU in Australian children and adolescents in collaboration with parents and schools. Based on findings of SBMU in a variety of environments, the authors conclude that “both parents and schools are enthusiastically embracing the digital age” (p. 9).

In the previous honours research (see p. 53) the data collection included an investigation to determine the feasibility of the hearing screening video game in a real-world environment. Surveys were used to gauge opinions of parents and health professionals regarding the use of video games for health applications for children. Results of the surveys determined that parents were very comfortable using video games for health and education with their children, and one participant stated that it “makes sense to use the technology available” (Brook, 2013, p. 37). From these results, it may be concluded parents are generally accepting of educational and health games for their children.
However, a study conducted in 2011, titled *Parental acceptance of digital game based learning*, revealed that “parents express rather negative beliefs about video games and are reluctant when it comes to using video games in educational settings” (Bourgonjon et al., 2011, p. 1435). The authors speculated how this may be attributed to the negative attention video games often receive in the media. This includes how violence in video games is often cited as leading to increased aggression and violent tendencies. The stance may also be influenced by Bandura’s (1965) work on social learning, and children’s tendency to imitate what they see.

Powers et al. (2015) agreed, stating “some have a false negative association with the medium due to unfounded news reports usually following a mass shooting” (p. 1). The authors also cite the benefits of video games, including:

- development of a child’s cognitive and intellectual skills such as higher order thinking;
- environments for young people to develop social skills, confidence and self-worth;
- common ground for children with disabilities to compete and interact with the abled;
- the facilitation of bonding through competition;
- mental health, by promoting positive moods and fostering creativity; and
- preventative health care, such as curbing pain thresholds and providing stress relief (Powers et al., 2015, "The Benefits of Gaming", para. 2-6)

From all reviewed literature, the impact of explicit content in video games on children is still heavily under debate, and numerous studies continue to produce conflicting results (Anderson et al., 2010; Azar, 2010; Ferguson, 2015; Freedman, 2002; Gentile & Bushman, 2012; Gentile, Li, Khoo, Prot, & Anderson, 2014). However, due to broad intra-personal and environmental factors, it is difficult to isolate video games as a primary contributor to any adverse psychological or behavioural changes (Lee
Thus, the influence of violence and explicit content in video games on children may never be known.

Regardless, the issue of violence in video games is a delimitation of this study. It is assumed that content, considered unsuitable for children, will be omitted by developers when designing video games for children. In addition, games which contain such material are expected to be classified as inappropriate for young audiences by media classifications organisations. One such organisation is Australian Classification, which provides age appropriate ratings for video games in accordance to the *Classification (Publications, Films and Computer Games) Act 1995* (2015).

Finally, it is important to note that the purpose of this study is not to investigate the positive and negative outcomes of SBMU. Instead, this section explores the growing trend in availability and usage of screen-based media, specifically video games, in young people. Video games have become an increasing part of young people’s lives and have taken the place of traditional activities. With increased availability and usage, there is potential for video games to be harnessed for both educational and health applications, including the DHH.

### 2.5 Interventional video games for the DHH

Prior to the commencement of this research, an Honours project titled *Analysing a new bilateral audiology test for children* was conducted by this researcher (Brook, 2013). The project investigated the potential of using a specially developed video game to aid in the diagnosis of hearing loss in children. As previously established, hearing loss is a growing health concern, and is known to have significantly high prevalence rates in Australian children (see p. 22). Left undiagnosed, a hearing impairment is proven to have an ongoing functional, social and emotional, and economic impact in a child’s life.
through to adulthood. This includes a delay in receptive and expressive communication skills; social isolation and poor self-concept; poor performance in classrooms and the inability to learn (O’Keefe, 2012; Timms et al., 2012; World Health Organization, 2017).

While telehealth solutions have been explored, such as mobile health clinics, many of these are hindered by factors such as restricted access due to seasonal environmental conditions and Aboriginal customary lore (see p. 2). As a result, a number of children with middle ear disease and hearing impairment remain undiagnosed (Bensink et al., 2010). It has been suggested that alternative telehealth solutions are required (Störbeck, 2012). Given the increase in children’s SBMU and availability of hardware (see p. 27), it was proposed that a serious game may be used to:

- facilitate self-administered hearing tests for children;
- aid in reducing the strain on existing telehealth services, such as mobile ear clinics; and
- complement similar solutions to achieve a holistic approach for diagnosing hearing loss and ear infection (Brook, 2013).

The following theoretical framework (Figure 1) was developed to represent how a serious game may provide a potential solution to the previously discussed problems. The independent variable (A), bacterial or viral middle ear infection, is directly influenced by (B), restricted access to immediate health services. According to Yiengprugsawan et al. (2013) and Weber (2012) limited access to health services in remote areas is believed to be a primary contributor to undiagnosed middle ear infection and resulting hearing loss.
Because of the relationship, between middle ear infections and restricted access to immediate health services at time \( t_1 \), the intervening variable \( D \), lack of diagnosis of hearing loss and ear infection, surfaces at time \( t_2 \). This can lead to \( E \) chronic suppuratives otitis media (CSOM) and ongoing temporary or permanent hearing loss at time \( t_3 \). It was proposed that the introduction of the moderating variable \( C \) a mobile hearing test, in the form of a serious game, would alter the relationships positively. This included the potential to increase the \( D \) diagnosis of hearing loss and ear infection, while reducing \( E \) CSOM, ongoing temporary or permanent hearing loss.

The research comprised development of a serious game for Apple iOS devices, in collaboration with industry experts from Telethon Speech and Hearing. The game was designed to emulate a professional gold standard hearing test, which is traditionally conducted in a calibrated and controlled environment. Once development of the serious game completed, field testing was conducted to determine accuracy, feasibility, and to provide proof of concept.
Testing of the serious game was conducted using sequential mixed-methods, consisting of three data collection methods— one quantitative and two qualitative:

- the quantitative method was conducted to determine the serious games’ hearing screening accuracy, in comparison to a gold standard hearing test;
- the first qualitative method involved the documentation of anecdotal records of each child’s behaviours, actions and responses during the testing process; and
- the second qualitative method included surveying audiologists and parents of child participants to obtain feedback on the serious game, and opinions on feasibility.

The quantitative testing included six child participants, both male and female, who were known to have a diagnosed hearing loss. Two child participants were tested in a controlled environment, utilising a sound booth at Telethon Speech and Hearing. Four child participants were tested in an uncontrolled environment. The results of the tests were output in standard audiogram format from the serious game. These results were directly compared to results of a traditional gold standard audiogram to verify accuracy.

The serious game was proven to produce accurate hearing screening results, with an acceptable 5 decibel (dB) margin for error, in accordance to international audiometry test protocol standards (International Organization for Standardization, 2010). However, this result was based on a small sample size. Several participants’ results were omitted due to unforeseen circumstances, primarily related to user interface and feedback design problems. These were later identified as issues related to hearing accessibility design considerations.
In accordance to existing video game accessibility guidelines, textual feedback was chosen as the primary visual feedback mechanic to complement audio feedback. However, as previously established, children with a hearing impairment often experience developmental delay. The areas which the DHH experience the most difficulty include language, communication and reading (Eden & Passig, 2000). The inability to hear instructions or read complementary text hindered the effectiveness of the serious game; and preliminary investigation also determined additional design choices may have impeded usability and accessibility. However, without reference materials, such as guidelines or academic research, these design limitations were unable to be identified. These findings led to the purpose of this research, which aimed to investigate how to better develop video games for the DHH.

In addition, a preliminary investigation was conducted into the area of accessible games designed for the DHH. It was determined that few academic publications related to the field exist. Those that do exist are relatively dated and tend to relate on the method of delivery, utilising specific forms of hardware such as virtual reality (VR), rather than a focus on video game software design (Adamo-Villani & Wright, 2007; Eden & Passig, 2000).

An example includes Improving the flexible thinking in deaf and hard of hearing children with Virtual Reality technology (Eden & Passig, 2000). According to the authors, performance assessments determined that DHH children attain “lower scores in flexible thinking than … children with normal hearing” (p. 1). To address the issue, the study investigated how cognitive function in DHH children was influenced when playing three-dimensional (3D) VR games. This specifically related to the long-term impact on cognitive function when manipulating 3D objects in VR games, in comparison to playing non-VR two-dimensional (2D) games. Participants were aged between 8-11 years, and included:

- an experimental group of DHH children, who played a 3D VR version of a game;
• a control group of DHH children, who played a 2D non-VR version of the same game; and
• a control group of children with normal hearing range, who did not experience any intervention at all (Hendley, 2002).

DHH participants played the games for 15 minutes, once a week, over three months. Performance assessments determined the experimental group of DHH children improved significantly, while the DHH control group showed minimal improvement. The authors concluded that the use of VR technology allows children to “realize their hidden potential without linguistic or auditory limitations” (p. 11). These results indicate that VR games may be more beneficial for improving cognitive function, and providing feedback, than a 2D video game.

However, the use of VR should perhaps not be relied on as a sole means of developing an accessible and developmentally appropriate game. As discussed in section 2.2 and 2.3 of this thesis, a large percentage of children who require early intervention reside in remote or rural areas, where the required VR hardware might not always be available. The reliance on VR has also been questioned by academics and industry experts. It is believed that, while VR may aid in providing feedback through physical and sensory immersion, it does not address general game design limitations in other forms of video games (McMahon & Ojeda, 2008, p.3). VR has limited direct applicability within accessible game software design, and it was decided that this research should instead focus on accessible software design, rather than hardware. As a result, feedback based on specific hardware, included haptic or tactile feedback, were omitted as an accessibility consideration for this research.

A similar study, titled A Virtual Learning Environment for deaf children: design and evaluation, discussed the development and evaluation of a prototype Virtual Learning Environment (VLE) using stationary VR
projection systems. The VR projection systems included light weight shutter glasses and a four screen VR display (Adamo-Villani, 2006). The study focused primarily on sensory and physical immersion, and evaluating the potential usability of the technology.

The VLE game was developed based on a user-centred design approach, rather than a standard developmental design framework. Design decisions were based on child participants’:

- physical, emotional and cognitive needs;
- preferences for visual style, including colour and lighting; and
- feedback from the target demographic (Adamo-Villani, 2006).

The resulting game utilised 3D avatars, which interacted with the player through American Sign Language (ASL). The avatars were used to teach mathematical terminologies and concepts, based on standard elementary school curriculum (Adamo-Villani, 2006).

Results of the study yield the importance of colour and visuals in students’ performance:

- a bright lighting setup with the presence of daylight is associated with improving students’ performance; whereas
- the use of de-saturated colours was found to have a negative impact on stimulation (Adamo-Villani, 2006).

However, results also identified issues with the game’s usability. It was determined that these issues stemmed from lack of appropriate forms of feedback, to guide the player and provide instruction, which the authors acknowledged was insufficient or non-existent. This resulted in participants becoming confused about which tasks to perform, and how to interact with the game environment. As a result, the authors stated that children would be expected to play the game with an adult present.
to provide feedback. As an alternative, future revisions of the game were expected to include additional feedback through sign language and way-finding methods. These concepts were not explored further.

It is important to note the reliance on sign language for feedback may have limited application. Like spoken language, there are various unique dialects of sign language around the world, and variations of those within individual communities. Australian Sign Language (Auslan) is the native language of the Australian Deaf Community, and is officially recognised by the Australian Federal Government. According to Auslan Signbank there are over one million people in Australia with some form of hearing loss - “very few of these people, however, would know or use Auslan” ("The deaf community," n.d., para. 2).

Further, children who have recently been diagnosed with a hearing loss, and require immediate early intervention, may not be proficient in sign language – unless they are exposed to it in frequented environments, such as at home, or if the child’s parents also suffer from a hearing loss. Based on the most recent statistics, this chance of this occurring seems highly unlikely, as “approximately 90 percent of DHH children are born to parents who can hear” ("The deaf community," n.d.; "Quick Statistics," 2010). As a result, Auslan is typically learned in later childhood “from adults outside of the family, such as at pre-school or school” ("The deaf community," n.d., para. 3).

The results of the previous Honours research, and preliminary analysis on approaches to the development of serious games for the DHH, provide further evidence for the need to address accessible game design limitations. While various approaches have been attempted, issues related to usability due to forms of feedback are not uncommon. To address the issue, it was important to conduct an analysis on the approaches to video game design, to determine how to best approach a
solution. This literature review therefore includes a discussion on the history of video games, video game formats, game design methods, and accessible game design.

2.6 History of the video game medium

The first video games are thought to have originated in the early 1950’s, as a means of demonstrating commercial technology and for academic research. They were usually available only to those who had access to computer labs at universities or large corporations. One such game, *Tennis for Two*, is often considered to be the first video game developed purely for entertainment. The game was developed by William Higinbotham at Brookhaven National Laboratory to entertain visitors during an exhibition in 1958 (Nyitray, 2016).

Commercial video games were not made readily available to the public until 1971. Nolan Bushnell, an employee of electromechanical games company Nutting Associates, created the first arcade monochrome video game *Computer Space*. Shortly after, Bushnell, along with Ted Dabney and Al Alcorn, went on to create video game company Atari, releasing the first hit video game *PONG* in arcades. *PONG* saw immediate success, and resulted in the proliferation of video games in arcades around the world. Video games steadily began to replace electromechanical arcade games and introduced game titles such as *Space Invaders, Pac-Man*, and *Defender*, which helped to “usher in the golden age of arcade video games in the 1980’s” (Wolf, 2007, p. 29).

When the aforementioned *Computer Space* hit the arcades, Magnavox introduced the first home video game console, the Odyssey. The game system allowed people, for the first time, to bring arcade games into their homes and became highly sought after. Other companies, such as Atari, Mattel, and Coleco, followed suit releasing their own home video game systems. These companies competed by advancing
the technology with each new video game system. This competition is a trend that continues today, and has contributed to the rapid advancement in video game technology (Winter, 2007).

Newer systems introduced colour graphics, improved controllers, the ability to save progress, and facilitated multiple players. However, these systems were still constrained by their software as additional games could not be purchased separately. All video game software came pre-installed on the systems, and consumers were forced to purchase entirely new machines to play newer games. It was not until 1976 that this changed, when the Fairchild Channel F video game system was released. The video game system featured a slot for inserting cartridges, which allowed video games to be programmed and sold separately. This change allowed consumers to purchase new games without having to buy a new video game system (Winter, 2007).

Dozens of new video game companies entered the industry releasing their own cartridge-based video game systems. The growing video game industry also resulted in the establishment of third party game development companies – those who would develop new games for other companies’ video game systems. However, only a few companies developed original content, and many of the third-party games were adaptations of existing well-known games (Winter, 2007). This oversaturated the market with clones, and the massive influx of poor quality video game titles resulted in loss of consumer interest. In turn, this led to the collapse of the video game industry in 1983, and many video game companies abandoning the industry (Wolf, 2007).

In 1985, Japanese video game company, Nintendo, entered the western market releasing the Nintendo Entertainment System (NES). This rebranded version of their Japanese video game system, the
Famicom, saw immediate success due to its large library of games. In turn, this helped to revive the American video game industry (Wolf, 2007).

Since the launch of the NES, the video game industry has seen continued growth with the rise and fall of video game system companies and video game developers (Wolf, 2007). As the underlying hardware for video games has advanced, video game systems have expanded to include home video game platforms such as:

- desktop, laptop, and tablet computers (Rehak, 2007);
- home consoles, including the most recent Sony PlayStation 4, Xbox One, and Nintendo WiiU ("PS4," n.d.; "WiiU," 2016; "Xbox One," 2016);
- handheld gaming systems, such as the Nintendo 3DS (Herman, 2007; "Nintendo 3DS," 2016); and
- mobile devices, such as phones, watches and glasses.

Video game software has also experienced significant advancement. Recent games feature:

- complex interactive storytelling, unfolding through player controlled actions;
- non-player characters programmed with simulated artificial intelligence assuming the roles of virtual actors; and
- advanced visuals, which have evolved from blocky low-resolution graphics to 3D rendered imagery. These visuals often attempt to replicate the real world to the highest level of fidelity using complex image-processing programs (Therrien, 2007).

Game audio has also advanced from simple blips generated by internal circuitry (Chang, Kim, & Kim, 2007) to “fully realized digital audio that rivals the output of the traditional music industry in fidelity and originality” (Pidkameny, 2007, p. 257). A game’s audio library often consists of extensive music
soundtracks, character dialogue, and sound effects to provide feedback, reflecting the player’s actions and choices. According to Pidkameny (2007), game audio “has progressed to the point where … [it is] no longer considered secondary to graphics or gameplay, but rather a part of the dynamic whole” (p. 256).

From this review, it can be surmised that while the underlying hardware and technology facilitates the capabilities of video games, the design of video game software is of equal or greater importance. Video game software can be generally thought of consisting of three primary components – the visuals, gameplay and audio, all of which contribute to the video game experience. The video game crash of 1983 provides evidence to support the importance of the design of video games, and without original and engaging gameplay to facilitate player engagement a game will not be successful. However, additional research is required to determine the role and significance each component plays in different genres and forms of games, and approaches to game design and development. Further, while video games have traditionally been used for entertainment purposes, the medium has also been used for other purposes, such as serious games.

2.7 Serious games, virtual worlds, and simulations

Serious games have become a frequent topic of discussion amongst industry professionals, and academics from multiple disciplines (Breuer & Bente, 2010). The benefits for education and training, scientific exploration, and health care are gaining significant attention (Marsh, 2011); and the serious games sector is touted as one of the largest growing industries, with a global growth rate of 15.4 percent (Adkins, 2012; Takahashi, 2013; "Serious games now $2 to $10 billion industry," 2012).

Annual events such as the Serious Games Summit, and the Games for Health conference, have provided greater awareness for the potential for serious games. This has fostered international support
from government agencies, and healthcare insurance organisations (Kharif, 2004). However, at the time of writing, there was no universally accepted definition for what constitutes a serious game. This posed a potential issue, as classification of specific video games was required to identify the approaches to the design and development of video games for this research.

The issue of serious game classification stems from whether the expression ‘serious game’ refers exclusively to video games used to inform and educate, or whether they are used for other means. This includes whether serious games are used to influence and persuade, to convey meaning, for experimentation and exploration, or for health and well-being. In addition, there is no clear distinction as to whether serious games encompass other forms of computer software, such as simulations and virtual/micro worlds. Further, it is unclear whether games developed inherently for entertainment, and utilised for serious purposes, can be classified as serious games. An analysis on published sources obfuscated the definition more, given the multidisciplinary approaches to investigation and implementation.

From the literature reviewed, the consensus is the terminology ‘serious games’ originated from Clark Abt (1975) (Breuer & Bente, 2010; Marsh, 2011; Ricciardi & De Paolis, 2014). In his book, aptly titled *Serious Games*, Clarke Abt (1975) proposed that serious games can be used to inform and instruct while providing a pleasurable experience. However, the definition primarily referred to the use of card and board games with an educational purpose.

This may explain why the most frequently disputed issue is whether the contemporary expression ‘serious game’ refers exclusively to video games used for educational and learning applications, or whether it extends to other domains. Moreover, the phrase is often used interchangeably with other
terms, such as ‘edutainment’, an amalgamation of the words educational entertainment; ‘edugame’, or educational game; ‘eLearning’; and ‘game-based learning’ (GBL) (Adkins, 2012; Gillin, 2014; Hinkley, Verbestel, Ahrens, & et al., 2014; Ratan & Ritterfeld, 2009).

In The complete guide to simulations and serious games, Aldrich (2009) recognised that “the lack of common terms is a huge problem, and it has substantially hindered the development of the simulation space” (p. xxxii). However, the author believed that the term serious game is exclusively used for educational applications, and “is the successor to edutainment” (p. xxxiv). Ricciardi and De Paolis (2014) agreed, stating that “is it clear that the learning function is mixed with the gaming nature of the application” (p. 2). The authors concluded “by comparing the definition of edutainment and the definition of serious game we can conclude that these two expressions refer to the same matter” (p. 2).

A slightly different perspective was provided by Michael and Chen (2005), who believed that “serious games encompass the same goals as edutainment, but extend … to all aspects of education: teaching, training and informing” (p. xv). Similarly, Derryberry (2007) noted “serious games are designed with the intention of improving some specific aspect of learning” (p. 3). The footnote provided further clarification that “serious games have other names, including learning simulations, digital game-based learning, [and] gaming simulations” (p. 3).

In A serious games continuum: between games for purpose and experiential learning, Marsh (2011) discussed how issues related to classification “could potentially have a detrimental effect on future research and development” (p. 67) of serious games. The author discussed issues faced with classification, including the impact of rapid advancement in underlying technology such as gaming environments and methods of interaction. This has resulted in “the proposal of definitions of serious games … being inaccurate
for the short term and redundant in the long term” (p. 61). In response, Marsh (2011) proposed a new classification of serious games:

Serious games are digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence, for well-being, and/or experience to convey meaning. The quality or success of serious games is characterized by the degree to which purpose has been fulfilled. Serious games are identified along a continuum from games for purpose at one end through to experiential environments with minimal or no gaming characteristics for experience at the other end (p. 63).

The classification is accompanied by a diagrammatic depiction of the serious games continuum (Figure 2). Using the continuum, serious games are divided into three sections: gaming activities with traditional characteristics such as challenge, play and fun; games and simulations with fewer gaming characteristics; and serious games with minimal gaming characteristics with a main purpose to provide experience and emotion, and to convey meaning.

Figure 2 Serious games continuum (Marsh, 2011, p.63)
The classification provides a comprehensive means of describing the various forms of serious games based on the intended experience, including the classification of video games developed for entertainment purposes and used for serious purposes. However, while perhaps unintentional, the classification proposed by Marsh (2011) includes another point of contention, as to whether simulations are classified separately from serious games. The inclusion of the term ‘simulation’ is not uncommon, and found in various literature related to serious games (Aldrich, 2009; Derryberry, 2007; Sawyer & Smith, 2008).

An investigation into commonly used terms, provided by Aldrich (2009), supports the interchangeable usage, stating that serious games and simulations are different terms for a similar concept. Sawyer and Smith (2008) attempted to refine this classification further, stating that the terminology ‘serious games’ is an umbrella term. This encompasses several genres of non-entertainment games, including educational games, micro/virtual worlds, and simulations, which are different implementations of a similar concept.

Qin, Chui, Pang, Choi, and Heng (2010) provided a different perspective, as depicted in Figure 3. According to the authors, traditional simulations attempt to replicate the real world to the highest level of fidelity and are fundamentally non-entertaining. In contrast, games sit on the opposite end of the spectrum, and are developed for the sole purpose of providing fun and entertainment. Simulation games are also referred to as virtual worlds, micro worlds or sandbox games and are thought to be purely imaginative in fictitious environments. These games might lack some traditional game elements, such as a narrative or linearity, but foster creativity. Serious games are thought to be a hybrid of both traditional simulations and entertainment games and are based in a realistic environment or scenario.
While this classification is perhaps the most comprehensive, and makes a clear distinction between the different video game formats, there are video games which do not conform to the classification. An example includes the videogame *World of Warcraft* (WoW) which has been developed as a simulation game, and contains specific objectives and game mechanics defining it as a game for entertainment. Using the Spectrum of Computer Games classification (Qin et al., 2010), WoW would be positioned on the spectrum between simulation games and games. However, WoW is also used for serious purposes.

The *World of Warcraft in School* program (Sheehy, 2016) is currently implemented in several middle schools in the United States and Canada for game-based learning. According to Sheehy (2016), WoW has been partnered with instructional learning materials and used as a “focal point for exploring Writing/Literacy, Mathematics, Digital Citizenship, [and] Online Safety” (para. 2). This example demonstrates a gap in the above classification model. Video games such as simulation games or entertainment games, that have been developed for a non-serious purpose and adapted for serious purposes, are unable to be appropriately classified.

From this review, it could be surmised that current negotiations on achieving a universally accepted classification or definition have potentially reached a temporary impasse. Numerous papers have been published in attempt to provide a standardised classification; however, these classifications models are...
unable to classify all forms of serious games. In addition, newer publications continue to provide contradictory definitions as “the domain boundaries of the Serious Games field are still subject for debate” (Djaouti et al., 2011, p. 2).

Because of these findings, it was determined that a new classification model for video games, serious games, simulations and virtual worlds was required. The purpose of this research was to determine how to foster accessible video game design for the DHH, which required an investigation into video game design approaches. While the classification model proposed by Qin et al. (2010) was the most comprehensive, gaps in the classification model were identified. Without an appropriate means of classifying the forms of video games, identifying specific approaches to video game design was not possible. To establish a new classification, the applications of serious game design were reviewed.

2.7.1 Applications of serious games

Of the publications reviewed for serious games, a clear majority discussed the use of serious games for education and training. This is because of the proven benefits, which are known to include:

- safe and cost-effective mechanisms for training;
- increased and maintained attention;
- accommodation for multiple learning styles;
- the ability to teach and expand on concepts; and
- increased retention of knowledge (Girard et al., 2013; Guillén-Nieto & Aleson-Carbonell, 2012; Li & Tsai, 2013; Papastergiou, 2009; "Solving the training dilemma with game-based learning," n.d.; Young et al., 2012)
According to Sykes (2006), educational serious games also incorporate “good principles of experiential learning” (p. 3), advocated by learning theorists such as Jean Piaget and John Dewey (Kolb & Kolb, 2009). This differs from a traditional stand-and-deliver approach to education. Learners are actively engaged in the content and motivated to participate as “every game offers a learning environment where mastery is rewarded—either by a high score, the introduction of a new item, or progression of the narrative” (Sykes, 2006, p. 3). Further, McMahon and Henderson (2011) believe the benefits for educational serious games stems from “the capacity to engage learners in ways that are often seen as more inherently rewarding than traditional educational experiences” (p. 3599).

In addition to the utilisation of serious games for education and training, the medium has also proven successful other applications. Some of these include:

- pain management (Ault, 2005);
- for research and scientific exploration using collective problem solving via games with a purpose (Toppo, 2012);
- therapy for managing phobias and stress disorders (Amon & Campbell, 2008; Kharif, 2004); and
- training surgeons and medical professionals (Cowan et al., 2011; Sabri et al., 2010).

Snow World is a serious game, utilising virtual reality (VR) technology, developed to aid in managing burn victim’s pain while undergoing treatment in hospital (Ault, 2005). The serious game utilises a head visor display, which monitors head movement, giving the patient a full 360-degree panoramic view of their environment. A sensor attached to the patient’s hand provides additional control, allowing them to throw snow balls and build snowmen (Gramza, 2008). Brain scans were used to measure pain levels, and results provided evidence that specifically developed serious games are
proven to be an effective analgesic, with a 90 percent reduction in reported pain levels in comparison to no treatment at all.

According to Steele, Thomas, Mulley, Fulton, and Hunter (2003), “uncontrolled pain can have serious psychological and physiological consequences, and may lead to an increased risk of morbidity and even mortality” (p. 633). Rehabilitation and post-surgery pain can be extremely painful and, in certain circumstances, pain analgesics may not be an option or may not provide adequate pain relief. As a potential solution, the researchers believe serious games such as Snow World may be most beneficial when used in collaboration with pain medication. Serious games for pain management are also expected to prove beneficial for patients unable to take traditional pain medication, such as pregnant women or people with medication allergies (Rumbelow, 2000).

A similar case study, titled Virtual reality as a pediatric pain modulation technique, was conducted to investigate the use of VR with children with cerebral palsy. The purpose of the study was to determine whether pain levels were reduced during regular physiotherapy following surgery. Results reported a 41.2 percent reduction in pain, reduced levels of anxiety, and increased motivation (Steele et al., 2003).

Further evidence for the use of serious games for health and well-being was provided by a study conducted at Sydney University. The study investigated the use of serious games for the management of stress and anxiety disorders. This included attention deficit hyperactivity disorder (ADHD) and post-traumatic stress disorder (PTSD). The serious game, titled Journey in to the Wild Divine, was found to increase attention span, improve memory recall, and translated to improved behaviour outside of the game (Amon & Campbell, 2008; Kharif, 2004).
Games with a purpose (GWAPs) are video games which engage with players to complete tasks that cannot be automated by a computer (Toppo, 2012). GWAPs are considered a practical application given the average American will participate in more than 10,000 hours of gaming by 21 years of age, which is the “equivalent to five years working a full-time job 40 hours a week” (Von Ahm & Dabbish, 2008, p. 58). The results of studies involving GWAPs have produced promising results, such as *Predicting protein structures with a multiplayer online game* (Cooper et al., 2010).

The study utilised a multiplayer online game titled *Foldit*, developed by researchers from the University of Washington. The game allowed non-scientist participants to assist in analysing a protein structure, aimed at preventing the growth of the AIDS virus in rhesus monkeys (Cooper et al., 2010; Toppo, 2012). The serious game was played by 236,000 people, who solved the molecular problem in 10 days, a solution that had remained unsolved by scientists for 15 years (Toppo, 2012).

From the reviewed literature, it can be surmised that serious games have been utilised for a wide range of applications. Numerous studies exist and provide evidence to support the claim that the serious games medium extends beyond education and training, to domains such as healthcare and scientific exploration. Based on these findings, a new classification was proposed.

### 2.7.2 New video game classification model

As identified in section 2.7 of this literature review, the term ‘serious games’ lacks a universally recognised definition. Existing classifications were found to be contradictory, specifically relating to whether serious games are used primarily for education and training, or whether the term encompasses video games for other domains. A review on related literature confirmed that serious games are used
for other domains, including for health and well-being and scientific exploration. As a result, a new classification model was developed.

Figure 4 is a representation of a new classification model for the Video Game Spectrum. The model includes a definition of simulations, serious games, virtual/micro worlds, and pure entertainment games. This definition is based on those proposed by Breuer and Bente (2010), Djaouti et al. (2011), Marsh (2011), the spectrum of computer games (Figure 3) proposed by Qin et al. (2010), and findings from this literature review.

![Video Game Spectrum](image)

**Figure 4 Video Game Spectrum (constructed from Qin et al., 2010)**

**Simulations**

Simulations appear on the left side of the spectrum, as the opposite to pure entertainment games. This includes any piece of software that attempts to replicate or imitate a real-world situation, scenario or system to the highest level of realism. Simulations do not include traditional game components, and may not require any human interaction at all. Thus, simulations are not considered serious games. An example includes artificial life programs such as a flocking-behaviour simulation, using the boids algorithm, to analyse characteristics and identify emergent behaviour of birds (Erneholm, 2011). While
the simulation has an inherently serious purpose, it does not contain core game components, excluding it from being classified as a serious game.

**Serious Games**

Serious games include “any piece of software that merges a non-entertaining purpose (serious) with a video game structure (game)” (Djaouti et al., 2011), and may be purposeful or adapted. Serious applications may be utilised for education and training; scientific exploration; engineering and planning; health and well-being; or for advertisement, including propaganda and developing awareness. While serious games include the serious aspect of simulations, they also include the five core gameplay mechanics found in pure entertainment games, and may be purposeful or adapted.

- **Purposeful Serious Games**

  Purposeful serious games are those that have been inherently designed for a serious purpose, from concept to creation. These types of serious games are usually developed for a specific demographic, and may be exogenous or endogenous.

  - Endogenous serious games include games where the serious purpose has influenced and informed the development of the gameplay, and is woven into the core structure of the game. Examples include the games Foldit (Cooper et al., 2010) and Snow World (Ault, 2005).

  - Exogenous games are those which utilise proven game designs and overlay the serious content without significant modification (Winn, 2009). An example of this form of game includes the game SL Invaders (Figure 5) ("SL Invaders," n.d.). The game is based on Space Invaders (Taito, 1978) and used for teaching multiplication to children.
Adapted Games

Adapted games are those that have been designed for entertainment/recreational purposes, and adapted for a serious application. These forms of games are generally tools, and considered a component of a much larger purpose. An example includes World of Warcraft, which has been developed as a virtual/micro world, with specific objectives and game mechanics defining it as a game for entertainment. However, the game has been adapted for use in education, when partnered with additional learning materials, reclassifying the game as an adapted serious game when used in an educational context (Sheehy, 2016).

Virtual/Micro Worlds

Virtual and micro worlds are also referred to as simulation games and sandbox games (Qin et al., 2010), and include both realistic or fictional worlds and scenarios. Simulation games differ from simulations, as they are primarily entertaining, and include the five core game mechanics found in pure entertainment games. However, unlike pure entertainment games, virtual/micro worlds do not usually define strict goals. Instead, virtual/micro worlds promote exploration, participation in virtual activities, and may include facilities for multiple users to interact. Examples of a virtual/micro worlds
may include open-world or sandbox games such as Second Life or Minecraft, which provide an open environment for users to explore, design, create and interact with others ("What is Minecraft?", 2016; "What is Second Life?", n.d.).

**Pure Entertainment Games**

Pure entertainment games are video games that have been developed primarily for entertainment purposes. These games include five core gameplay mechanics, including “the various actions, behaviours and control mechanisms afforded to the player within a game context” (Hunicke, LenBlanc, & Zubek, 2004), defined in the following table:

<table>
<thead>
<tr>
<th>Goals</th>
<th>A “milestone the player has to accomplish to continue progressing through the game” (Ojeda, 2007). Goals may be predefined, or player created, and are generally made explicit through feedback. According to Mullich (2016), goals should be clearly defined, obtainable, challenging, rewarding, concrete, and provide immediate feedback.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge</td>
<td>Provides the player with the ability to test and develop their skills, and is dependent on factors such as goals, feedback and rules (Ojeda, 2007). According to Csikszentmihaly (1990, cited in Chen, 2007) the difficulty of challenge should be balanced with the player’s ability to achieve flow. Flow is “the feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfilment” (p. 31). In addition, a game should provide direct and immediate feedback of the challenging activity and goals, to maintain user engagement and attention (Baron, 2012; Chen, 2007; McMahon &amp; Ojeda, 2008).</td>
</tr>
<tr>
<td>Rules</td>
<td>Govern what the player can and can’t do in the game. Rules are a mandatory component, and one of the most important, as they define how the game world operates, but also how to achieve goals or reach a win state (Ang, 2006). Examples</td>
</tr>
</tbody>
</table>
include game rules, which govern physics and movement; and narrative rules, such as requiring the player to complete a task before progressing to the next level.

| Boundaries | A physical and/or narrative barrier, used to restrict player movement or progress. Examples of physical barriers include a wall, door, river or mountain, preventing the player from accessing or leaving a location in the spatial game world. Narrative boundaries are “an element of the story of the game which explains our inability to continue onward” (Griffiths, 2008). Boundaries may be permanent or temporary, requiring the player to complete a specific task or satisfy an objective (goals) before the boundary is removed. |
| Feedback | An internal game system which notifies the player of their “progress in terms of goals, challenges, skill development, and control” (Ojeda, 2007). Feedback may visual, including any imagery appearing on a display; auditory, sound produced by and for the game; or hardware based, including haptic or tactile feedback. |

The development of this new classification model overcomes the limitations of those previously reviewed. A comprehensive definition has been provided and permits the classification of various forms of video games— including serious games. Serious games are proven to be beneficial for various applications, and the new classification model acknowledges those.

However, McMahon & Ojeda (2008) believe “there are lessons to be learnt from previous incarnations” (p. 2) of serious games, and it “is vital that the wave of enthusiasm for serious games does not oversell that potential” (p. 2). Others agree, stating additional research is required to establish industry standards, and the development of reference materials for developers (Yuan et al., 2011). Without additional research, it will inevitably lead to the unsuccessful development of serious games (McMahon & Ojeda, 2008).
This was evident in the previous research conducted by this researcher (see page 33). The serious game, which was developed to aid in the diagnosis of hearing loss in children, was based on existing accessibility guidelines and an academic game design framework. However, results of the study determined that existing game accessibility guidelines and development frameworks lacked specificity for hearing accessibility considerations. This ultimately led to design choices which hindered the accessibility and accuracy of the serious game. Based on those results, and with the new video game classification model, an analysis on game design methods was conducted.

2.8 Game design methods

On commencement of this review, it became apparent that there is interchangeable usage of the terms ‘model’ and ‘framework’. Both terms are used to refer to a visualised or documented, systematic process to guide the development of a desired output, or to support the identification of solutions to a given problem. For example, in information systems and software development, a framework is used to “structure, plan, and control the process of developing an information system” ("Software Development Methodologies," n.d., para. 1). Similarly, models can be defined as a means of “identification and definition of the final system and its functionalities prior to its actual development” (Hunt, 2011, p. 13). Due to the interchangeable usage of both terms, and for the sake of clarity, the terminologies ‘framework’ and ‘model’ will continue to be used synonymously for this thesis.

A preliminary analysis on design frameworks, used for designing video games, determined that those targeted towards video game development were sparse, or suitable for a specific application. Depending on the developer and target demographic, it has become common practice for instructional design models or software development frameworks to be utilised in game design. However, these
types of frameworks often lack core game design principles, leaving developers with a non-prescriptive template to scaffold game design.

These findings are in line with a study conducted by Hunt (2011). The study provided an analysis on frameworks for game design, with the inclusion of frameworks for software and information systems development. Findings of the study determined that “the majority of existing development models have been created for use in the field of software systems development [including simulations] and, while they can be adapted for game development, are not specifically tailored for use by games developers” (pp. 17-18).

Because of initial findings, and evidence provided by the above study, frameworks which are not exclusively targeted towards video game development have been omitted from the review. Further, of the frameworks identified to foster game development, three distinct categories have been identified. These include instructional design models, game design frameworks, and game assessment frameworks (Figure 6).

![Figure 6 Framework Relationship](image-url)
2.8.1 Instructional Design Models

Instructional Design Models (IDM) are “systematic guidelines instructional designers follow to create a workshop, a course, a curriculum, an instructional program, or a training session” (McGriff, 2001, cited in "Instructional Design Models and Methods," 2012). At its core, the process generally involves identification of the needs of a learner, defining a learning goal, and developing a means of achieving that goal via a specific method of delivery. Numerous instructional design models exist, including the ADDIE model, the Dick and Carey Model, Bloom’s Taxonomy, Kemp’s Instructional Design Model, and Gagne’s 9 Events of Instruction ("Instructional Design Models and Methods," 2012). While video games may be utilised as a method of delivery, IDMs are not exclusive to game design, and typically do not provide a framework for the design of video games (McMahon, 2009).

IDMs can be utilised to aid video game designers in developing educational content in serious games, in conjunction with a Game Design Framework (Figure 6). However, they are considered ancillary, and outside the scope of this study. Thus, IDMs have been excluded from the review, unless explicitly defined as a framework for video games.

2.8.2 Game assessment frameworks

Game assessment frameworks are those that facilitate the analysis of existing video games or aid developers in a specific stage of the game design process. An example includes A game genre agnostic framework for game-design, proposed by Tremblay and Verbrugge (2015). The study presents a new framework, which game developers can use to beta-test games to ensure balance and fairness. This is performed using artificial intelligence (AI), in place of a human player, to reduce financial expenditure and time-consuming labour of user play-testing.
In *Purposeful by design?: a serious game design assessment framework*, Mitgutsch and Alvarado (2012) introduce a new game assessment framework as a means of analysing and assessing serious game design. The authors state that the framework has been devised to “compensate for the lack of assessment tools” (p. 1), and the fact that “serious games are often deemed successful if they generate discussion and attract attention - [however] the quality of the game design or the actual impact on the players remains mostly unobserved” (p. 1). It was the authors’ belief that the game assessment framework may be used to gauge serious game limitations and potential, and generate constructive discussion, criticism and further exploration.

Game assessment frameworks, such as these, may aid in a specific stage of game development, used in conjunction with a Game Design Framework (Figure 6), or for assessing video games. However, existing game assessment frameworks do not provide guidance for developers to create or assess accessible video games. It was determined a new game assessment framework may prove beneficial as a potential solution to aid game developers in designing accessibility solutions, and for analysing accessibility in their games.

**2.8.3 Game Design Frameworks**

The game design frameworks included in this review consist of published or publically available documentation, which aid developers in the design and development of a video game from concept to creation. Results determined that existing game design frameworks can generally be divided into two distinct categories. For this study, these have been defined as generalisable and targeted game design frameworks.
2.8.3.1 Generalisable Game Design Frameworks

Generalisable game design frameworks provide a basis for developers to create a game with cohesive gameplay mechanics, with little or no consideration for individual users. These frameworks generally focus on the design of pure entertainment games and virtual worlds, and provide minimal focus on elements beyond gameplay design. While there may be some consideration for the player, these frameworks focus on how to elicit an expected generalised emotional response, rather than an individual user’s experience. Examples of these types of frameworks include the Mechanics, Dynamics and Aesthetics (MDA) model (Hunicke et al., 2004), and the Action, Gameplay and Experience (AGE) model.

MDA Model

The Mechanics, Dynamics and Aesthetics (MDA) model is possibly the most renowned approach to game design, both in academia and in the game design industry. The MDA model is often cited as having an influence on the design of newer frameworks (Dillon, 2012; Winn, 2009).

The MDA model consists of three components (Figure 7):

- Mechanics, which describes game mechanics at the core level, including data representation and algorithms, and can be considered the rules and boundaries of the game;
- Dynamics, which relates to feedback and behaviour of the game, as a response to player input, during run-time; and
- Aesthetics, which relates to the desired emotional response from the player when they engage with the game (Hunicke et al., 2004).
It is believed that aesthetics is the most challenging part of the MDA design process, as the developer only has direct control over the mechanics. It is the responsibility of the developer to determine what emotional response they wish to elicit from the player through the game mechanics. The process is iterative, with amendments to mechanics and dynamics made after user play-testing, to achieve the desired aesthetics (Hunicke et al., 2004).

The model does not include any reference to accessibility, or identification of a specific target audience or individual’s experience. Instead, the model focuses on how to elicit emotional responses from a generalised demographic. According to Winn (2009), the MDA framework “has proven to be a useful approach to designing and analysing gameplay” (p. 1013), however, “it does not specifically address aspects of game design beyond gameplay” (pp. 1013-1014).

**AGE Model**

The AGE model is based on the MDA framework, and aims to “guide students and beginning game designers in the process of formalizing their ideas in a coherent and consistent fashion” (Dillon, 2012, p. 1). The model segments game development into three layers:

- Actions, which includes any input the player may have, and the resulting in-game event or ‘action’;
• Gameplay, which is defined as high-level concepts resulting from the combination of actions; and

• Experience which, like the MDA framework, refers exclusively to a player’s emotional response or instinct (Dillon, 2012).

While the MDA model focuses on what emotions the developer wishes to elicit from the player, the AGE model also identifies eleven instincts, which can be relied on to “provide players with a meaningful and fun experience” (Dillon, 2012, p. 4). However, the model does not provide guidance on how the developer may elicit emotion or instinct in the player, nor does it discuss collaborating or engaging with the target audience at any point during the design process. Further, accessibility is not acknowledged as a consideration in the design process.

2.8.3.2 Targeted Game Design Frameworks

Targeted game design frameworks are those which require the designer to consider a specific target audience or demographic during design and development. These frameworks are commonly found in serious game design. The design process is mostly iterative, and typically requires user consideration throughout. Targeted frameworks differ from generalisable frameworks, as they are interested primarily in a specific target audience’s user experience. Examples include the Design, Play, and Experience framework (Winn, 2009); the Document-Oriented Design and Development for Experiential Learning Model (McMahon, 2009), and the Four-Dimensional Framework (de Freitas & Jarvis, 2006)
**DPE Framework**

The Design, Play and Experience (DPE) framework (Winn, 2009) is “an expansion of the MDA framework to address the needs of serious game design for learning” (p. 1014). The DPE framework provides additional focus on the individual user, stating “the experience of one player may be profoundly different than the experience of another player. The target audience for the game must be strongly taken into account throughout the design process” (p. 1014). To achieve this, the author introduces the inclusion of several components, specific to serious games (Figure 8).

![DPE Framework and Subcomponents](Winn, 2009)

The learning and storytelling layers of the framework depict the instructional design component, which includes method of delivery, and how content design links to learning outcomes. The gameplay layer relates to what the player will do in the game, which has been directly adapted from the original MDA framework. The User Experience layer is perhaps the addition which is most relevant to this study, as the author states that the layer “encompasses everything the user sees, hears, and interacts with and how that interaction happens” (Winn, 2009, p. 1018). However, no additional information is provided on how the developer should design video games suitable for the target audience, and there is no mention of accessibility considerations.
4C/ID-Model

The 4C/ID-model is an instructional design model used for designing learning environments, and reducing cognitive load during the learning process (Wenhao & Johnson, 2011). While the original model was not developed explicitly for video game design, Wenhao and Johnson (2011) adapted the model in their study Instructional game design using cognitive load theory. The study discussed how their instructional design framework can be utilised to improve instructional video game design. Instructional video games are recognised as a form of serious games, used for education and training.

The framework identifies several gameplay characteristics, such as rules, goals and challenge, and discusses how these can be designed to create an effective learning environment. However, the framework provides no guidance on the design or development of a video game outside of these characteristics. For example, the authors mention the importance of feedback, and how feedback can be used to provide the player with supportive information. However, no additional information is provided on how feedback should be designed or implemented (Wenhao & Johnson, 2011).

As a result, it was determined that while the framework may aid in the development of instructional material in educational serious games, it lacks specificity. The framework would be most beneficial when utilised in conjunction with a game design framework.

DODDEL Model

Potentially the most descriptive, and detailed, framework reviewed is the Document-Oriented Design and Development for Experiential Learning (DODDEL) model (McMahon, 2009). The DODDEL model is “designed to facilitate teaching and learning about serious game design, while providing a sound basis for communication about the process within teams, and among teachers, clients and
developers” (p. 3). The model uses an iterative approach, where progress flows from concept through to implementation, and iteration occurring within each phase.

The model facilitates identification of a specific target audience early in the design process, as part of the Situation Analysis (Figure 9). In addition, the author states that the “methodology itself is flexible enough to accommodate a range of learning approaches and game types” (McMahon, 2009). However, there is no guidance on how game mechanics should be developed to cater for a specific audience, nor any acknowledgement of accessible game design.

![Figure 9 The DODDEL Model (McMahon, 2009)](image)

### 2.8.4 Predictive and Adaptive Approaches to Design

In addition to a systematic approach to design, using developmental frameworks, it has been determined that there is an alternative approach to video game design. In an extensive literature review
of current development practices by Hunt (2011), recent trends in game development were analysed. Two vastly different approaches to game design were identified, defined as predictive and adaptive.

Predictive approaches are those which conform to traditional systems development methodologies, such as the previously discussed video game design frameworks. These involve “comprehensively planning as a separate task prior to actual development” (Hunt, 2011, p. 18). Predictive development is common in mainstream game development, as a means of controlling scope, development time, and cost; and maximising return on investment with proven game formats. This approach to development is considered standard, both within mainstream industry and in academia. Further, in the researcher’s experience, predictive design is also beneficial in educating novice and student developers.

In contrast, adaptive development approaches generally have little to no pre-planning, and rely on “using multiple iterations and prototypes to shape a game and its design based on [user] feedback and analysis” (Hunt, 2011, p. 18). Adaptive development is becoming more common in the independent game development industry, where individuals or small teams operate with limited resources and budgets. Pre-planning is given minor consideration, and the iterative process of rapid prototyping, play-testing, and revision is the primary focus. As a result, independent development has become a testing ground for new ideas. This has resulted in increased popularity and economic values of independent games ("Back to the Garage: The Return of Indie Development ", 2012; Hunt, 2011; Brightman, 2015).

Contemporary independent video game development is reminiscent of the ‘golden-age’ of video game design, during the mid-1970s and early 1980s. During this time game developers often funded and
developed video games in their homes and garages, and distributed their software independently ("Back to the Garage: The Return of Indie Development ", 2012; Kushner, 2004). Independent developers would often venture out as game developer entrepreneurs. This was likely in response to reports that large video game companies often exploited employees, and “refused to give designers royalties for games or even name credits on the game boxes” (Dyer-Witheford & de Peuter, 2009, p. 10). One such example includes Atari when, after its acquisition by Warner Communications in 1978, “employees defected to start their own game companies” (p. 13) due to discontent with their working conditions. This resulted in the creation of the third-party game development sector, and the founding of game developers such as Activision, id Software, Cyan, and Origin (Dyer-Witheford & de Peuter, 2009; Kushner, 2004).

Since then, the video game industry has experienced massive growth, and become a vast industrial enterprise. Considering this, some believe the industry has become subject to further corporate domination ("Back to the Garage: The Return of Indie Development ", 2012; Dyer-Witheford & de Peuter, 2009; Brightman, 2015). Companies, such as Electronic Arts (EA), have evolved from developers, expanding into publishing and licensing of third-party intellectual property (IP) ("About Electronic Arts," n.d.). While EA continues to develop its own video games in-house, their role as a publisher facilitates the development of video games by external developers. This facilitation includes the provision of financial support, as well as manufacturing, marketing, distribution and advertising. However, this publisher-developer relationship has become subject to criticism. Critics have voiced opinions that companies such as EA have “pioneered methods of accumulation based on intellectual property rights, … transcontinentally subcontracted dirty work, and world-marketed commodities”, and “are media constitutive of twenty-first-century global hypercapitalism” (Dyer-Witheford & de Peuter, 2009, p. xxix). According to Lanning (cited in Brightman, 2015), publishers’ terms have
become progressively worse for developers, which involves “doing 10 times the work, but you’re going to get a fifth of the backside because … [publishers are] risking all this money” (para. 5).

In addition, according to Dyer-Witheford and de Peuter (2009), “all but the largest or most famous developers must surrender creative control and intellectual property rights” (p.43). It has also become common practice for developers, which prosper, to be acquired and absorbed by the publisher. Schiesel (2008, cited in Dyer-Witheford & de Peuter, 2009) believes publishers will often purchase development studios, “essentially running them into the ground because the … [publisher] did not allow those studios to maintain their creative independence” (p. 43). As a result, employees of the acquired developers will often resign, and start the cyclic process again “following the dream of small-company autonomy and creative freedom” (p.43).

Some now consider the game industry to be “witnessing an indie renaissance” ("Back to the Garage: The Return of Indie Development ", 2012, "Overview", para. 1). According to Lanning (cited in Brightman, 2015), many independent developers are now able to operate without the necessity of a publisher. Instead, developers can utilise alternative, low-cost methods to develop, market and distribute their games. Digital distribution platforms, such as Steam ("Steam Greenlight," 2016), Google Play ("Google Play Developer Console," 2016), and Apple’s App Store ("Submitting Your Apps," 2016), provide facilities for developers to market and sell their games. As a result, “the independent can now go directly to the customer … then they have a chance to actually succeed and keeping making more stuff” (Lanning cited in Brightman, 2015, para. 15).

However, operating without the financial backing of publishers means independent developers are often unable to dedicate time to pre-planning. Instead, many independents have adopted an adaptive
design process, involving rapid prototyping, testing and evaluation of their games. This approach is thought to promote creativity, allows for greater risk taking, with the option of being able to cease development and start anew if the project fails (Lanning, cited in Brightman, 2015).

Stephens (2009) agreed and stated that a predictive approach to “design, implementation and testing doesn’t work well for small teams or for games in general” (para. 5). The author believed that predictive design may also lead to “burnout and misguided design decisions” (para. 5) for independent developers. Furthermore, generalisable design frameworks provide focus on design to produce an expected emotional response from the player. However, Stephens believes that while games “are about fun, and, increasingly other emotional responses” that it may be “almost impossible to predict from a design alone whether it will resonate with audiences” (“Iterative Design”, para. 2).

Based on findings of this review, it was evident that there are various approaches to the design of video games. It was determined that this required further investigation, and would aid in forming the first research question. In addition, it was determined that accessibility is often overlooked as a consideration in game design methods, and further investigation into accessible video game design was required.

### 2.9 Accessible video game design

There are varied definitions of the terminology ‘accessibility’, whether referring to environment, transportation, general media, or technology. However, few definitions relate specifically to video game design. Those that do are often lengthy discussions, providing in-depth explanations of individual disabilities, in attempt to define or classify video game accessibility (admin, 2012; "Making Video Games Accessible: Business Justifications and Design Considerations," 2013; Yuan et al., 2011).
Two notable exceptions include those provided in the Game Accessibility Guidelines and by the Game Accessibility Special Interest Group (GA-SIG).

The description provided in the Game Accessibility Guidelines notes that “accessibility means avoiding unnecessary barriers that prevent people with a range of impairments from accessing or enjoying your output” ("Why and how," n.d.). However, this lacks specificity for the video game medium as the definition does not stipulate what constitutes a barrier or impairment. As a result, the definition and was deemed unsuitable for this thesis.

The GA-SIG provides a more descriptive definition, in a white paper titled *Accessibility in Games: Motivations and Approaches*:

Game Accessibility can be defined as the ability to play a game even when functioning under limiting conditions. Limiting conditions can be functional limitations, or disabilities – such as blindness, deafness, or mobility limitations (Game Accessibility Special Interest Group, 2004).

This classification was found to be the most comprehensive and succinct. It was for this reason that the GA-SIG definition was adopted for this thesis. In addition to the above findings, the lack of literature related to video game accessibility was found to extend beyond solely classification.

Except for organisations dedicated to video game accessibility and a select few developers, there is little published discussion from developers of video games regarding accessibility. This may be due to “the movement to have accessible video games [being] small, unorganized and misdirected” (Powers et al., 2015, p. 1). However, the lack of discussion is not due to unawareness for the need for accessibility.
An informal survey conducted by the AbleGamers Foundation (2009) determined that approximately 69 percent of video game developers had considered how people with disabilities play video games. The lack of accessible games may be primarily due to insufficient knowledge regarding implementation. During the survey, one participant stated that, they “thought about it … [but] didn’t really come up with any solutions” (AbleGamers, 2009). In a review of related literature, others believed that progress is hindered by negative assumptions associated with accessible design (Jarvis, 2015); or that the issue must first be addressed through legislation and law (Powers et al., 2015).

In relation to the negative assumptions associated with accessible design, Ian Hamilton, co-author of the Game Accessibility Guidelines ("Game Accessibility Guidelines," n.d.), believed that many developers have a general attitude that, "accessibility is a wasted effort, … time-consuming, difficult work just to water down your idea to a lowest common denominator for a tiny minority who wouldn't even want to play games anyway" (Moss, 2014, "Globetrotter", para. 3). Advocates for video game accessibility believe such assumptions are false, and “there are a number of reasons why game developers should think about making their products accessible” (Zahand, n.d., "Why should developers care?", para. 1). Application of accessibility in game design is beyond ethical practice. There is a range of benefits including:

- potential increased revenue by catering to an already interested demographic;
- increased media attention by leading the accessibility movement;
- encouraging creativity for designers; and
- benefitting the abled general gaming population by providing additional options to improve user experience (Moss, 2014; Powers et al., 2015; Zahand, n.d.).

Further, Powers et al. (2015) states that “even if the cited benefits did not exist, there is still no justification for the lack of accessibility standards” (“Why video game accessibility matters”, para.2).
The movement for video game accessibility resides predominantly in online communities and organisations. The online deaf community consists of numerous groups, is highly proactive, and recognised by the video game industry as being responsible for implementation of standards and practices in mainstream media. These standards and practices insist on subtitles and visual cues being in place to assist those with hearing impairments. An example of an online community group is Games[CC] (closed captioners), which “is a dedicated group of captioners, translators, artists and programmers who modify existing games to add closed captioning” ("About Games[CC]," n.d.-a, para. 1). Not-for-profit organisation, AbleGamers Foundation, praised the deaf community for their involvement, and have stated that there is still room to improve in video game accessibility (Bartlet & Spohn, 2012).

In response to the demand for better accessibility guidance from game developers, the AbleGamers foundation released Includification. Includification is a descriptive accessible design document for developers of video games. The document does not explain the technical ways to design a video game; it outlines:

- the most important accessibility options; and
- detailed explanations of common problems for gamers with disabilities and solutions for those problems (Bartlet & Spohn, 2012).

The document is not specifically targeted towards developers of serious games, or games developed for children with a hearing impairment. Instead, the authors have presented several suggestions for consideration by developers of all video games. The accessibility recommendations are presented in four categories, including:

- mobility impairments;
• visual impairments;
• cognitive impairments; and
• hearing impairments.

The hearing impairments section is the shortest in the document. The section suggests that video games “should be designed in a way such that the game can be completed whether the sound is enabled or not” (p. 28). This is referred to as the Baby-friendly Test, a new concept defined for video game hearing accessibility. The terminology is derived from the belief that not all players, who require hearing accessibility, are DHH. For example, parents of babies may “play video games […] with the sound disabled and the baby sleeping right beside them” (Bartlet & Spohn, 2012, p. 28). Adhering to the Baby-friendly Test involves being able to play a game with the game muted, and ensuring no adverse impact on the user’s experience or gameplay.

To achieve baby-friendliness, accessibility considerations discussed primarily rely on text-based options to complement or substitute audio feedback. Under the three category titles of good, better and best, the discussion of baby-friendliness provides the following information:

Table 2 Hearing accessibility categories of Includification

<p>| | |</p>
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| Good  | • subtitles for spoken sound  
       | • closed captioning for both spoken and other audio cues                              |
| Better| • inclusion of changeable fonts and text colours for increased visibility in closed  |
|       |   captioning and subtitles                                                         |
| Best  | • inclusion of ambient sounds in closed captioning                                  |
|       | • use of alternative reactionary devices                                            |
Alternative reactionary devices include visual cues or haptic feedback as alternative forms of feedback. Visual cues, which are also referred to as subliminal cues, include any form of visual feedback in a game that explicitly complements or substitutes audio feedback. An example provided describes how the screen may flash red when a character is low on health or becomes increasingly wounded. Haptic feedback refers to the use of hardware devices to provide feedback, such as a vibrating controller to indicate that the player has taken damage. Few additional examples are provided. However, the authors identify that non-audio cues are important, as they allow “the gamer to interpret important game information … without having to hear anything” (p. 30). In addition, “to a hearing impaired gamer, these types of warning systems are an essential feature to level the playing field” (Bartlet & Spohn, 2012, p. 30).

The *Includification* document is informative presenting some unique ideas, and addresses some of the issues often encountered with subtitles and closed captioning. Subtitles and captions in video games currently lack a legal standard, resulting in a vast difference in quality of subtitling and captioning. The AbleGamers foundation also questioned the reliance of a universal design approach for video game development.

Universal design refers to a one-size fits all approach to the “design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (Skulski, 2007, "Accessible Design vs. Universal Design", para. 3). This differs from other design methodologies, such as:

- prescriptive design, which relates to design specifically tailored for a demographics’ (dis)ability; or
accessible design, which relates to video games that are developed for the wider demographic, while meeting the needs of individuals with functional limitations or disabilities (Bartlet & Spohn, 2012; Skulski, 2007).

In other areas of digital media, such as Web, universal design is facilitated by a variety of tools, resources, and best practices guides for compliance. According to Bartlet & Spohn (2012), adding accessibility to websites has become relatively easy, and a web “developer can only feign ignorance or laziness in most cases when challenged on the missing accessibility features in his or her content” (p. 8). However, the same approach is not currently feasible in video game design, due to various challenges. These challenges include:

- the ever-evolving nature of video game technology;
- the various genres, platforms and environments in which games are developed;
- real-time gaming in massively multiplayer environments; and
- lack of available tools and adaptive technology.

Due to these challenges, the best practices of universal design cannot be applied to video game design, and such an approach may never be feasible. As a result, Bartlet & Spohn (2012) believe that “we need to consider an alternative approach to including people with disabilities in the gaming space that acknowledges that 100% inclusion is not feasible” (p. 8). Instead, their goal “is to make gaming as accessible as technology will allow to the widest group of people with disabilities on a game-by-game basis” and “for those left out of a particular title, there are other titles waiting for them to play” (p. 9). This approach is confirmed in the Game Accessibility Guidelines, who aim to “ensure that games are just as fun for as wide a range of people as possible” ("Game Accessibility Guidelines," n.d., "About the Guidelines").
The *Game accessibility guidelines* are a web-based resource, like the *Includification* document. Authored by game developers, academics and industry professionals, the guidelines aim to provide “a straightforward reference to inclusive game design” ("Game Accessibility Guidelines," n.d.). The guidelines were initially published in 2012, and are presented as a living document. It is important to note that, as a living document, the information contained in this review was relevant at the time of writing, and the source may have since been updated or amended.

The guidelines are categorised into areas of accessibility, including motor, cognitive, vision, hearing, and speech. The accessibility considerations are further divided into sub-categories from basic, to intermediate, and advanced. Sub-categories are based on the number of people who may benefit, the potential impact, and the cost of implementation. The hearing category in the guidelines is both extensive and informative with greater prescription than the *Includification* documentation. To achieve hearing accessibility, the three sub-categories provide the following recommendations:

<table>
<thead>
<tr>
<th>Table 3 Summary of Game Accessibility Guidelines hearing accessibility recommendations</th>
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<tr>
<td><strong>Basic</strong></td>
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<tr>
<td><strong>Intermediate</strong></td>
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<tr>
<td><strong>Advanced</strong></td>
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79
Each recommendation includes a short description, and some with best practice examples. Unlike the Includification documentation, the Game accessibility guidelines do not make a clear distinction between subtitles or closed captions. In Game accessibility guidelines, ‘best practice examples’ of current video games are provided based on applications of certain accessibility in video games. However, examples and the discussion of methods for implementation of accessibility are limited.

After reviewing existing industry guidelines and literature available from industry and community, it was determined that current resources are limited. Guidelines were found to rely primary on the use of textual feedback, with a focus on formatting and presentation of text. In addition, recommendations for additional forms of feedback, such as visual indicators and haptic feedback, were common. However, this lacked specificity regarding methods of implementation. Further investigation determined that these limitations are not confined solely to industry. The field of video game accessibility in academia has also received minimal attention.

A clear majority of reviewed academic publications have been found to focus on other video game accessibility domains, with minimal attention to hearing loss. These include:

- motor or physical impairments, with discussion on single-switch gaming, and touch-less interaction ("Accessible Game Controllers," 2005; Altanis, Boloudakis, Retalis, & Nikou, 2013; Judge & Colven, 2006; Kearney, 2005; Sundstedt, 2010);
- the elderly (Gerling & Masuch, 2011; Ijsselsteijn, Nap, Kort, & Poels, 2007); and
- visual impairments, with discussion on enhanced visuals, tactile interfaces and haptic feedback (Atkinson, Gucukoglu, Machin, & Lawrence, 2006; Park & Kim, 2013; Rober & Masuch, 2005; Westin, 2004; Yuan et al., 2011).
Discussion relating to audio accessibility tends to focus on the increased reliance on audio for players with visual impairments. This includes ways in which games can be designed around an auditory experience (Torrente et al., 2014). Alternatives to the visual representation of audio information is less common, and there are limited resources available to aid in the development of video games for users with a hearing loss. Further, information that relates to hearing accessibility are generally components of larger studies.

In *Guidelines of serious game accessibility for the disabled*, Park and Kim (2013) identified the need for accessibility guidelines for serious games. Confirming claims by Bartlet and Spohn (2012), in the previously discussed *Includification* document, existing World Wide Web Consortium (W3C) guidelines were analysed and deemed inappropriate for use in game design. This is because video game developers “can’t follow all regulations about web accessibility due to the basic function of the game” (p. 2). A new approach to accessible game classification was proposed and subdivided into three categories:

- technical accessibility;
- game content accessibility; and
- game playing interface accessibility (Park & Kim, 2013).

The technical category refers to the four principles of web accessibility, which are perceivable, operable, understandable and robust. These are not fully explored, and it is unclear how they can be utilised or relate to the game design process. The game content category describes game mechanics. Provided are two recommendations- restriction of the number of player and non-player characters available at any one time; and ability to control the game speed. No justification or evidence is provided to support the category. Finally, the game playing interface refers to the hardware interface, specifically...
input devices. The brief description states the category relates to “both hands interface, multiple keyboard, mouse and joystick” (p. 2). No additional information is provided for this category.

Further considerations are provided, including the identification of a specific demographic and disability class prior to the commencement of development, and considered in all planning stages. Based on the game accessibility classification, six guidelines for accessible serious game design were introduced:

1. Define the serious game goal and area of disability;
2. Plan the scenario, including the characters, story, genre, and target age;
3. Plan the game components, including puzzles and quests;
4. Plan game rewards, to increase the effect of training;
5. Plan training, which relates to assessment of the player and balance of difficulty and challenge; and
6. Plan training effects and achievement to foster replayability.

On review, it was determined that the guidelines closely resemble a game design framework rather than accessible design guidelines. When compared to the serious game design frameworks identified in section 2.8 of this thesis the planning guidelines were deemed inadequate. There is limited discussion on accessible design, no discussion of different forms of disability, or any discussion on the technical design of a game.

Towards a low cost adaptation of educational games for people with disabilities is a study conducted to determine how to facilitate accessible video game design by adding support in game design software. The study recognised that “making games accessible is a very complex issue that requires taking different actions across multiple aspects of the game” (Torrente et al., 2014, p. 371). The study does not explicitly
provide guidance on how to implement accessibility; it discusses how eAdventure, a game authoring program, can be used to develop accessible educational games.

The discussion for making games accessible for children with a hearing loss is minimal, because eAdventure is used for creating text-based adventure games. This led the authors to believe that the DHH are those who require the least attention as the most common approach for hearing accessibility is “to replace the audio information with text using techniques like subtitling or close captioning” (Torrente et al., 2014, p. 374).

This thought process is not uncommon amongst those who specialise in accessible design, with the belief that “deafness is fairly well catered for across the board, [as] the majority of games across platforms have subtitles” (Media Access Australia, 2014, para. 20). This may be an acceptable approach for users with a moderate to proficient reading ability. However, it has been previously established that children with a hearing loss may suffer from developmental and learning delay, impeding skills such as reading comprehension.

Current statistics show that Australian children, without a learning difficulty or developmental delay, commence learning to read from 5 years of age, achieving reading comprehension proficiency between 9 to 11 years (Dickenson, 2014, p. 10). However, as discussed in section 2.3, children with a hearing loss may experience developmental and learning delay, and reading comprehension is one of the most difficult skills to master. This is due to:

- Limited language input in the home, such as from parents and siblings, in early childhood and during the sensitive periods for language acquisition;
- Greater difficulty learning vocabulary, grammar, word order, and other aspects of literacy;
• Challenges related to understanding what is being read, not only reading the words;
• Lack of appropriate strategies or methods in traditional schooling environments to support students and improve literacy skills; and
• Minimal progress in developing strategies to improve critical literacy skills, regardless of decades of dedicated research (Bickham, 2015).

As a result, “the reading skills of many deaf children lag several years behind those of hearing children” (van Staden (2013), cited in Bickham, 2015, p. 3), and can extend through to secondary schooling and adulthood. Issues related to reading comprehension for the DHH make textual reliance unsuitable for younger audiences. In addition to textual feedback, Torrente et al. (2014) recognised that barriers for participants, who are DHH, may arise when “essential information or parts of the plot are conveyed only using audio”. This leads to a consideration of replacing audio feedback with visual stimuli.

The recommendation for visual stimuli as a substitute for audio is also made in Game accessibility: a survey (Yuan et al., 2011). The purpose of the survey was to identify current research and practices in accessible video game design. Like the previous study, the focus is on the wider aspect of accessibility, with minimal discussion on accessibility for participants who are DHH.

The authors presented a game interaction model (GIM) to identify how certain disabilities may impede player interaction. The GIM consists of three stages: receive stimuli, determine response, and provide input. Results determined that video games may be classified as having:

• primary visual stimuli, and secondary audio stimuli; or
• primary visual and audio stimuli.
Games with secondary audio stimuli were considered to still be playable by the DHH, with a minimal adverse impact on their experience. Games with primary audio stimuli were considered to have a significant adverse impact on the player’s experience, to the point where a DHH participant may be unable to perform at all (Yuan et al., 2011). The authors further extended their findings by suggesting the substitution of audio with text and the potential for the use of visual cues such as:

- visual indicators to highlight which game objects are making sound in the game environment;
- using radar to indicate the source and direction of game audio; or
- sign language to communicate with the player (Yuan et al., 2011).

The discussion in the study, along with the results, highlight several points of interest. The first is the role game audio plays in individual games, whether primary or secondary. The second is the relationship between visual and auditory feedback, and how visual indicators may be used to complement audio. These findings are not dissimilar to what was proposed in the reviewed game accessibility guidelines. As a result, it was determined that the relationship between visual and auditory feedback required additional investigation for this research.

A review of literature related to accessible design has also determined that the movement is steadily gaining momentum in industry, academia and the wider community. However, hearing impairment is often provided minimal attention. Developers, accessibility experts, and academics tend to share the belief that hearing accessibility is well catered for. The common approach for hearing accessibility is to utilise subtitles and closed captioning, with a strong focus on the formatting and presentation of textual feedback.
However, this approach is currently insufficient because there are no international standards for closed captions or subtitles. In addition, reliance on text-based solutions may also be unsuitable for the DHH, particularly children, due to a symptomatic developmental and learning delay. This learning delay is proven to have an adverse impact on reading comprehension, negating the effectiveness of subtitles and captions for some DHH audiences.

Alternative hearing accessibility solutions frequently suggest the implementation of alternative forms of feedback, such as visual cues and haptic feedback. This is in line with findings in section 2.7.2, where video game feedback was defined as being auditory, visual, and haptic (see Table 1 Five Core Gameplay Mechanics). However, it is important to note that reliance on specific hardware solutions, such as haptic feedback, may not be a feasible approach or solely relied on for hearing accessibility. As previously identified in section 2.6, video game hardware is frequently changing, and there are various hardware platforms available for video games. As a result, not all video game hardware will support solutions such as haptic feedback. A brief analysis on common out-of-the-box video game consoles supports this position:

Table 4 Video game hardware haptic feedback support

<table>
<thead>
<tr>
<th>Video Game Platform</th>
<th>Haptic Feedback Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nintendo DS/2DS/3DS</td>
<td>No</td>
</tr>
<tr>
<td>PlayStation Vita</td>
<td>No</td>
</tr>
<tr>
<td>Xbox One/S</td>
<td>Yes (included controller)</td>
</tr>
<tr>
<td>PlayStation 4/Pro</td>
<td>Yes, (included controller)</td>
</tr>
<tr>
<td>Nintendo WiiU</td>
<td>Yes (included Gamepad)</td>
</tr>
</tbody>
</table>

It is important to note that Table 4 excludes video game platforms such as personal computers and mobile phones, due to the vast array of devices available. It is likely that mobile phone devices would
support haptic feedback via an internal vibration function. PC gaming platforms however, such as laptop and desktop computers, primarily use a mouse and keyboard for input controls. These input devices commonly lack any form of haptic feedback.

Due to the unpredictability of available hardware support, and rapid advancement in video game hardware, it was decided that a software based approach would be the most appropriate hearing accessibility solution. Visual forms of feedback were identified throughout this review, as an alternative to audio, including:

- subtitles and closed captions;
- visual indicators to highlight objects of interest; and
- sign language.

Each of these require additional investigation, as does the relationship between game audio and visual feedback. The focus area for this research was therefore refined to focus on how visual user interface (UI) elements of a video game may be utilised to complement audio in video games. Results would then be used to develop a means of selecting and implementing those visual UI elements in a video game during the design process to complement different forms of game audio.

### 2.10 Formation of research questions based on the literature review

Review of literature, related to the design of games for the DHH, and a preliminary investigation into the development of accessible video games, provided the primary research question:

*Primary Research Question: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?*
However, additional review of literature was required to develop a better understanding of what was required to answer the primary question. This included literature related to video game medium, game design methods, and accessible game design. Based on the results, it was concluded that additional research was required into the following areas, to achieve a means of facilitating accessible game design for the DHH:

- identification of a means of facilitating the different approaches to game design;
- an analysis on the different types of sound used in video games and the function of those sounds;
- an analysis on the different visual elements utilised in video games, to provide greater specificity than the current recommendations in accessibility guidelines and academic studies;
- triangulation of the data collected, to determine how visual game feedback elements may be classified, and utilised as an alternative to specific forms of game sound; and
- determine whether the results can be formulated into a systematic approach to facilitate existing game design practices.

These findings formed the following sub-questions, to support the primary research question:

*Sub. Research Question 1.1:* What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?

*Sub. Research Question 1.2:* What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?
2.11 Chapter summary

This chapter first discussed the incidence of hearing loss and the associated developmental and learning delay experienced by children. From the reviewed literature, it can be surmised that hearing loss and the resulting developmental and learning delay are a critical concern for the public health sector. Hearing loss may be congenital or acquired, which is the most common form of hearing loss in children affecting more than half of all Australian children. Unfortunately, there are currently no known preventative measures to address acquired hearing loss (e.g. otitis media). Undiagnosed hearing loss can result in ongoing temporary or permanent hearing loss; and early diagnosis and intervention is considered the optimal solution. However, lack of immediate access to health professionals compounds the problem further.

To address the issue, of undiagnosed hearing loss, middle ear disease, and restricted access to early intervention, it has been determined that additional or alternative solutions are required. A review on previous research identified potential solutions, in the form of serious games, to aid in diagnosis of hearing loss and early intervention in children. However, limitations in the appropriate accessible design of these games were identified. These limitations were found to adversely impact the effectiveness of such solutions, and other forms of video games for the DHH.

Reviews revealed existing methods and resources related to accessible game design for the DHH are inadequate or unsuitable for specific audiences. The most common approach to hearing accessibility is using textual feedback, which is considered unsuitable for DHH children. Reliance on solutions related to hardware, such as VR or haptic feedback, were also deemed unsuitable. Additional alternative approaches referred to the use of supplementary visual feedback. However, relatively few examples toward implementation exist. Extending on these results, new subsidiary research questions
were developed. These questions focused on determining the relationship between visual and auditory feedback, and investigated how these may be utilised to increase the level of accessibility.
Chapter 3: Research Design

3. Overview of chapter

This chapter presents the transformative mixed-methods methodology, action research (AR) method as a framework, and methods involved in collecting and analysing data. The methodology has been chosen after exploring quantitative, qualitative and mixed methods approaches. The strengths and limitations of the chosen method are also described. The research design details the data collection and analysis, recruitment and sampling, ethical considerations, and limitations and confounding factors. This is presented in the following sections:

- **Section 3.1** introduces the underpinning theoretical framework and the conceptual framework for this research.
- **Section 3.2** presents and justifies the chosen transformative mixed methods methodology, and application of action research within the chosen methodology.
- **Section 3.3** describes the cyclic process of action research as a data collection framework.
- **Section 3.4** discusses the data collection process and analysis method.
- **Section 3.5** addresses ethical considerations for the research.
- **Section 3.6** identifies and addresses the limitations of the research methodology.
- **Section 3.7** provides a summary of the chapter.

In chapter 2, the literature review critically analysed the incidence of hearing loss, issues related to diagnosis and treatment, and the need for alternative solutions to address those issues. In previous studies, serious games for education and health were identified as a potential solution to aid in diagnosis and early intervention. However, issues related to the suitable design of serious games for
the deaf and hard of hearing (DHH) were identified, impeding user engagement and interaction. These issues included:

- existing approaches to video game design, both prescriptive and adaptive, lacking appropriate accessibility considerations for the DHH;

- feedback relying on specific hardware, such as virtual reality, tactile and haptic feedback. As this research focused on developing accessible video game software, for the DHH, hardware based solutions were considered a limitation of this research; and

- accessibility guidelines for the DHH recommending:
  - textual feedback, which was deemed unsuitable for children; and
  - alternative forms of visual feedback, which lacked specificity for implementation, requiring further investigation.

It was also determined that the same video game accessibility guidelines and design methods are often used in serious games, virtual worlds and purely entertainment games. This resulted in the scope of accessible design issues for the DHH expanding to encompass all forms of video games. These findings led to the purpose of this research, which was to identify a means of facilitating accessible design of video games for the DHH. Based on these findings, a primary research question was formed:

*Primary Research Question: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?*

To address the primary research question, the research conducted investigation into:

- methods of developing video games, and a means of facilitating accessible design for each method; and
• identification of the forms of visual and auditory feedback used in video games, to determine what visual feedback elements may be used to substitute audio.

Data obtained from these investigations were used to determine how to best amend existing video game design practices. To accomplish this, two subsidiary research questions were raised:

Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?

Sub Research Question 1.2: What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?

To address the first subsidiary research question, an analysis on game design methods was conducted in the literature review. This was further refined and modelled in diagrammatic form in the first research cycle. In turn, this led to:

• a better understanding of different approaches to video game design;
• identification of relationships between video game design methods; and
• the identification of a suitable approach to facilitate accessible video game design.

To address the second subsidiary question, the research identified a means of categorising the different forms of visual and auditory feedback used in video games. Using the classification method, individual forms of visual and auditory feedback elements, and relationships between those methods, were identified through analysis of video games. This resulted in identification of suitable alternative visual forms of feedback. This was achieved by:
• developing a means of identifying and classifying video and auditory feedback elements in video games;
• analysing existing video games, using the new classification method, to tabulate the forms of visual feedback which had been previously used to complement audio; and
• using the collected data to identify which forms of visual feedback can be used as an alternative to specific forms of audio feedback.

In addition, the research included a survey to gather data related to the implementation and use of alternative forms of visual feedback, including subtitles and captions, in video games. In the literature review, subtitles and captions were found to be frequently cited as a primary form of visual feedback for hearing accessibility. An analysis on user opinions and use of the forms of feedback enabled the researcher to identify how textual feedback may be best used to complement audio feedback and to facilitate hearing accessibility.

Lastly, the research triangulated the findings from each of the subsidiary research questions to answer the primary research question. The results were used to develop a means of facilitating accessibility for the DHH in the different approaches to video game design. Figure 10 shows the approach of this research in diagrammatic format, and is further described in this chapter.
3.1. Theoretical and Conceptual Framework

This section describes how the theoretical and conceptual frameworks were derived for this research. Theoretical frameworks are commonly used to represent theory or concepts to explain a pre-existing research problem. Conceptual frameworks may be defined as the synthesis and arrangement of concepts or theories derived from literature to explain, predict or better understand a new research problem (Imenda, 2014). As this research was informed by previous research and theory, this section was broken down into two independent diagrams to differentiate previous research from this research:

- a **theoretical framework** (3.1.1), based on a preceding research problem and theories. The theoretical framework underpins the conceptual framework; and
- a **conceptual framework** (3.1.2), representative of this research problem, and derived from critical analysis of literature. The conceptual framework embodies the specific direction of how the research problem was explored.
### 3.1.1 Theoretical Framework

Figure 11 represents the current state of hearing loss, influencing factors, and the symptomatic developmental delay and learning difficulty often experienced by children who are DHH. Serious games developed for children who are DHH are depicted as a new moderating variable, which have been theorised to influence a state of change (Adamo-Villani, 2006; Adamo-Villani & Wright, 2007; Brook, 2013; Eden & Passig, 2000).

The independent variable (A), undiagnosed hearing loss, was found to be heavily influenced by (B) limited access to health services and specialists. This was especially prevalent in (C) remote locations, where paraprofessionals were employed to aid in screening hearing. However, these approaches were found to be impeded by external factors, resulting in a large percentage of children remaining undiagnosed. Without diagnosis, and access to services, early intervention does not occur.
Independent variable (D) mainstream schooling access represents issues relating to children’s access, support, and performance in schools. This is because, in developing countries “children with hearing loss and deafness rarely receive any schooling” (World Health Organization, 2017, "Economic impact", para. 1). In addition, those who do attend mainstream schooling without aid, in both developing countries and the developed world, were found to perform poorly.

Poor performance has been attributed to developmental and learning delay, and high levels of stress and fatigue. Stress and fatigue is the result of additional mental or cognitive effort expended to listen to and process information (American Speech Language and Hearing Association, 2004). In addition, many schools were found to lack appropriate strategies or methods to support DHH students, and minimal progress has been made in developing strategies regardless of decades of dedicated research (Bickham, 2015).

The consensus is that alternative and improved access to health and education services is required, to improve diagnosis and access to early intervention services (Bensink et al., 2010; Störbeck, 2012; World Health Organization, 2017). Without additional solutions, to address diagnosis and limited access to services, the independent variables at t1 will continue to have an adverse impact on (F) – i.e. access to early intervention at t2. This could ultimately lead to (G) further developmental delay, learning difficulties and an ongoing impact throughout life at t3 (Bickham, 2015).

To address the issue, it has been suggested that alternative telehealth and tele-education solutions are required. In response, serious games have been developed for diagnosis (Brook, 2013), and early intervention (Eden & Passig, 2000; Adamo-Villani, 2006). This is depicted in the moderating variable (E) – i.e. serious games for telehealth and tele-education. It has been proposed that these solutions
would vastly improve diagnosis, access to early intervention (F), and potentially reduce (G) developmental delay and learning difficulties. However, as identified in the literature review, there is a need for improved hearing accessibility in video games. These findings led to this research and informed the conceptual framework.

3.1.2 Conceptual Framework

Figure 12 is representative of the current state of serious games development for DHH children. As identified in the literature review, the (C) non-prescriptive hearing accessibility guidelines and game design frameworks have had a direct influence on (B) game design practices. This has resulted in (A) impeded user engagement and interaction.

![Conceptual Framework for this research](image)

The independent variables at ($t_1$) have been proven to have an adverse impact on (E), the development of suitably accessible games for the DHH at ($t_2$). In the literature review, it was determined that accessible game design issues have negatively impacted user engagement for the DHH. In turn, this
had adversely influenced the effectiveness of the serious games, and continued research and development of such strategies.

This is due to existing game design practices relying on game design frameworks and guidelines, which have been found to be insufficient for informing accessible design for the DHH. Existing solutions tend to rely on hardware, such as virtual reality, or textual feedback including subtitles and closed captions. These approaches to game design have ultimately resulted in limited use of serious games for health and education applications, for children with a hearing loss, at (f).

The introduction of the moderating variable (D)– i.e. additional research – is the representation of this study. Additional research into accessible game design to cater for the DHH could potentially result in (E) development of suitably accessible games. In turn, this could lead to (F) the wider use and implementation of serious games for health and education applications and children who are DHH. This research approach, including the underlying methodology and method, is described in section 3.2.

3.2 Methodology

Transformative mixed-methods (TMM) was chosen as the methodology for this research. The methodology employs the practices of both qualitative and quantitative research and requires the selection of a framework which allows a stepwise approach with action, critical reflection and revision to guide the research design. The selection of framework is based upon the researcher’s theoretical lens and anticipated outcomes of the study. In addition, the framework informs specific methods for data collection and analysis, and guides the direction of the study based upon emerging results.
The selection of methodology was made after an in-depth assessment and analysis of the different methodologies.

According to Creswell (2003), research methods can typically be defined as belonging to either a qualitative or quantitative methodology. The choice of method is determined on research questions, underlying methodology of research, and the researchers’ theoretical perspective. In addition, each strategy of inquiry differs vastly in what type of data is collected, how it is collected, and analysed. Qualitative research does not involve numbers or numerical data (Creswell, 2003). Instead qualitative research methods rely on the collection and analysis of language, imagery, and observations to explore phenomena and develop understanding (Mack, Woodsong, MacQueen, Guest, & Namey, 2005; Marti, 2015). These research methods are useful for investigating topic areas where little is known; or to gain a deeper understanding of what is already known (Creswell, 2003). For example, a qualitative method would be useful in describing how and why phenomena occur, such as behaviours, opinions, and beliefs of a specific population (Mack et al., 2005).

Qualitative methods typically consist of an investigation (Mack et al., 2005), which:

- poses an open-ended research question;
- identifies a systematic process to investigation;
- collects and analyses textual data such as field notes and audio-visual material, using methods including interviews, observations, focus groups, self-studies, case studies, and action research; and
- reports findings:
  - that were not known in advance, to provide an original contribution to knowledge; and
which are applicable beyond the study, to inform future research.

The design of a qualitative research study also allows for some flexibility in study design. Iteration is a qualitative feature, which permits the adjustment of research questions or data collection methods depending on what is learned. In addition, the information obtained in a qualitative approach is generally considered to provide greater insight and deeper understanding of a phenomenon under study (Mack et al., 2005).

Quantitative research involves the collection of numerical data, and subsequent analyses or measurement using mathematical, computational and statistical methods (Creswell, 2003; Martí, 2015). If numbers are not involved, then it is not quantitative research (Creswell, 2003). Methods which fall under this methodology involve (Creswell, 2003; Mack et al., 2005):

- generating hypotheses or closed-ended research question(s);
- careful design of the method, including identification of materials and instruments prior to data collection, such as surveys, polls, questionnaires or structured observations;
- finding evidence to support or refute the hypothesis, including collection of numerical data from instruments and observations; and
- explaining results by modelling variables and relationships in diagrammatic format rather than purely textual forms.

The study design of quantitative research is highly structured and consistent throughout. The goal of quantitative research is to determine the relationships between variables (Mack et al., 2005). Thus, the approaches to research generally fall into one of two categories (Creswell & Plano-Clark, 2011):
• experimental, which involves testing before and after to determine causality, including laboratory and field experiments; or
• descriptive, which typically involves a single test to determine associations between variables, including quasi or natural experiments.

Objectivity is considered a key component in quantitative research. As such, researchers often adhere to strict standards for validity and reliability. This scientific rigour ensures competent inquiry and the ability to replicate or repeat the process (Creswell, 2003).

In addition to qualitative and quantitative methodologies is the mixed methods methodology (Creswell, 2003; Creswell & Plano-Clark, 2011). Mixed methods research involves the combination of elements from both qualitative and quantitative methods (Lingard, Albert, & Levinson, 2008). Creswell (2003) believed mixed methods exists because “the situation today is less quantitative versus qualitative and more how research practices lie somewhere on a continuum between the two” (p.4).

As a methodology, mixed methods include philosophical assumptions. These assumptions guide the direction of collecting, analysing and mixing qualitative and quantitative approaches throughout the research process. The assumptions are:

• the researcher chooses which method to use to answer a specific research question; and
• the researcher conducts the study, anticipating the results based on own values and explanations (Creswell & Plano-Clark, 2011).

As a method of inquiry, it focuses on collecting, analysing and mixing both quantitative and qualitative data in a single study or series of studies (Creswell & Plano-Clark, 2011). This involves the process of triangulation, where “the results from one method help develop or inform another method” (Creswell,
2003, pp. 15-16). This can be achieved by using either a sequential, concurrent or transformative process (Table 5).

Table 5 Mixed Methods Approaches- Adapted from Creswell (2003, p. 211)

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Priority</th>
<th>Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequential- Qualitative First</td>
<td>Qualitative</td>
<td>• During data analysis; or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• During data interpretation</td>
</tr>
<tr>
<td>Sequential- Quantitative First</td>
<td>Quantitative</td>
<td>• During data interpretation; or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• With some combination</td>
</tr>
<tr>
<td>Concurrent</td>
<td>Equal</td>
<td>• At data collection</td>
</tr>
</tbody>
</table>

Sequential mixed methods strategies require the investigator to decide on a principle data collection method, either qualitative or quantitative. The research is then followed by a method from the alternative methodology. Results of one method are used to inform, support, and provide greater understanding for another method during an integration period. For example, a Qualitative First study:

- gathers qualitative data in the first method;
- quantitative data during a second stage; and
- integrates results from both methods during the data analysis or interpretation stage.

The priority of methods employed is dependent on the investigator, but must be determined prior to commencement of the study (Creswell, 2003).

Concurrent mixed methods strategies permit the researcher to conduct both qualitative and quantitative methods simultaneously. The data from both methods is integrated during the interpretation stage. Results of this strategy usually form a component of a larger data collection procedure, to aid in analysing more complex research questions (Creswell, 2003).
Transformative procedures rely on the framework of a theoretical perspective to guide the research design and may be sequential, concurrent or a combination of both. The strategy is often employed to address issues of social justice and marginalisation - i.e. when the research problem has been identified as being an issue of discrimination or oppression, or community concern. Theoretical perspectives include, but are not limited to: feminist, disability inquiry, lifestyle, class or social status perspectives. In addition, transformative mixed methods research has been critical in the establishment of action-oriented research as a credible research method (Creswell, 2003; Tashakkori & Teddlie, 2003). Examples include advocacy and participatory action research, which seeks to “pursue action (or change) and research (or understanding) at the same time” (Dick, 1999, p1, cited in Williams, Scott, & Pain, 2010).

### 3.3 Justification for selection

Based on the analysis of research methodologies, a transformative mixed-methods methodology was chosen for this research. A mixed methods approach was considered a practical choice as the core characteristics aligned with the nature of the research inquiry- including the research questions, aims, and outcomes. This included (Creswell, 2003):

- the anticipated outcome of this research being the improved design of accessible video games for the DHH, aligning with the purpose of TMM to promote change and advocate for marginalised groups (p. 16);
- the research questions requiring the gathering of data for integration at different stages of enquiry to identify a potential solution to the problem. This aligns with a core characteristic of TMM employing the mixing of data at different stages (p. 19).
• The research questions requiring triangulation of results from the two sub-research questions, with triangulation being a core characteristic of mixed-methods (p. 219); and
• The methodology permitting both qualitative and quantitative methods of inquiry as the research demanded (p.19).

The research methodology is also in-line with the researcher's pragmatic world view. Pragmatism advocates the use of mixed methods in research (Creswell, 2003), with the belief that “quantitative and qualitative methods are compatible because they have enough similarities in fundamental values” (Ivankova, 2014, p. 51). These methodological similarities include (p. 51-52):

1. following the same steps to designing and conducting studies;
2. using empirical data to draw conclusions; and
3. using validation techniques to safeguard study conclusions.

Due to the selection of a transformative mixed methods methodology, a choice of compatible methods to serve as a framework for the data collection and analysis was required. Table 6 describes the methods explored, including advantages and limitations of each. This was based on the compendium of qualitative methods by Creswell (2013), and the taxonomy of information systems research approaches by Galliers and Land (1987).

Table 6 Description of analysed research methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Key points of method</th>
<th>Advantages of method</th>
<th>Limitations of method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative Laboratory Experiments</td>
<td>Investigates the relationship between variables, before and after testing, to determine causality and test hypothesis.</td>
<td>• Statistics are clear and unambiguous • Conducted in a controlled environment, permitting replication • Selection and control of variables</td>
<td>• Requires rigorous design • Can be fixated on generating results rather than the overall picture. • Does not necessarily translate to ‘real world’ applications, due to exclusion of external variables. • Participant behaviour may alter when they are aware of their participation</td>
</tr>
<tr>
<td>Quantitative Field Experiments</td>
<td>Experimental research undertaken in the field, such as within an organisation or.</td>
<td>• Better real-world validity than laboratory experiments</td>
<td>• Similar to laboratory experiments for rigorous design and generation of results.</td>
</tr>
<tr>
<td>Method</td>
<td>Information</td>
<td>Advantages</td>
<td>Disadvantages</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Quantitative Descriptive</td>
<td>Investigates the association between variables, using a single test. Includes quasi or natural experiments.</td>
<td>• Possibility to include large sample sizes, which would not be possible in a laboratory setting • Difficult to control and predict variables • Access to field locations may not always be possible</td>
<td>3. Effective for providing analysis on non-quantified topics 4. Permits the observation of a phenomenon in a natural and unchanged environment 5. Provides opportunity for integration with qualitative methods. 6. Majority of descriptive studies are not repeatable due to observational nature</td>
</tr>
<tr>
<td>Survey</td>
<td>Qualitative and quantitative data are collected using questioning, to generalise from a sample to a population. Results provide descriptions of a situation, event or activity. Often used in cross-sectional or longitudinal studies.</td>
<td>• Quantitative survey data provides a rich narrative description. • Quantitative survey data provides statistical validity, and can accurately reflect the thoughts, beliefs and feelings of a population.</td>
<td>• Quantitative surveys can result in superficial understandings of participant's thoughts, beliefs and feelings. • Qualitative surveys may not be generalizable to the larger population.</td>
</tr>
<tr>
<td>Case Study</td>
<td>Uses a variety of data collection procedures, over a period, to explore a program, event, activity or process (a case).</td>
<td>• Useful for hypothesis generation • Simplifies complex concepts • Useful for social sciences, behavioural and anthropological studies. • Allows study of phenomena without affecting behaviour • Useful when ethical considerations may arise from using methods which require direct contact with subject under study. • Allows for both qualitative and quantitative data collection methods to be used. • Aids in explaining the complexities of research, which may not be captured through experimental or survey research. • Can be used to disprove a theory.</td>
<td>• Can suffer from bias and subjectivity of interpretations by the researcher • Lack of generalisation to a larger population. • Can be time consuming, difficult to conduct, and produces significant amounts of documentation. • May not be suited for shorter durations. • Cannot be used to prove a theory.</td>
</tr>
<tr>
<td>Action Research</td>
<td>Similar to case study approaches, using a variety of data collection procedures. However, the process is cyclic, and adds critical reflection to influence future cycles.</td>
<td>• Same as case studies • Critical reflection and iteration allows for flexible and responsive research design • Has direct outcomes for practice. • Focuses on pragmatic and solution-driven research, rather than testing theories.</td>
<td>Same as case studies for issues relating to generalisation and subjectivity. • Time consuming and complex to conduct. • Difficult to write up, as it does not fit within a standard format to report findings effectively.</td>
</tr>
<tr>
<td>Phenomenological</td>
<td>As a method, involves studying participants over a prolonged period. Participants are those who have a shared experience concerning a phenomenon. Results are analysed, by detailed and in-depth understanding of phenomena. Rich data is collected from the experiences of individuals.</td>
<td>• Detailed and in-depth understanding of phenomena • Rich data is collected from the experiences of individuals.</td>
<td>Difficult to detect or prevent researcher bias • Highly qualitative nature of results can make presentation of results difficult.</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Advantages</td>
<td>Disadvantages</td>
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<tr>
<td>Ethnographic</td>
<td>Typically involves the collection of observational data, over an extensive period. Used to analyse a cultural group in a natural environment.</td>
<td>- Suited to complex issues that are not suited for quantitative method.</td>
<td>- Difficult to replicate, as results are applicable to the subjects under study and the researcher.</td>
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<td></td>
<td>- Permits various data collection methods, such as participant observation and interviews.</td>
<td>- Requires competency in interviewing methods.</td>
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<td></td>
<td></td>
<td>- Difficult to replicate, as results are applicable to the subjects under study and the researcher.</td>
<td>- Requires understanding of group or culture under study, and often involves investigation of issues relating to cultural sensitivities.</td>
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<td>- Time consuming, and required researcher to develop trust with participants.</td>
<td>- Difficult to detect or prevent researcher bias.</td>
</tr>
<tr>
<td>Qualitative Interviews</td>
<td>Includes individual interviews and group interviews, such as focus groups. Interviews are generally unstructured, and may be conducted in person, via phone, email, web forum etc. Analysed using qualitative methods to determine participant’s opinions and beliefs from responses.</td>
<td>- Useful when the participants cannot be observed.</td>
<td>- The presence of the researcher may influence the participant's responses.</td>
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<td>- The researcher has control over the questions asked.</td>
<td>- Provides indirect information filtered through the views of the interviewees.</td>
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<td></td>
<td>- Unlike quantitative surveys, participants can provide additional information.</td>
<td>- Articulation is dependent on the individual participant.</td>
</tr>
<tr>
<td>Qualitative Observational</td>
<td>The researcher records field notes documenting participants' actions, activity, and opinions. May include questioning of participants. Analysed using qualitative methods.</td>
<td>- Useful for exploring topics which may be uncomfortable for participants to discuss.</td>
<td>- Can be intrusive for participants</td>
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<td>- Information is recorded as it occurs</td>
<td>- Sensitive information may be recorded</td>
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<td></td>
<td></td>
<td>- Provides detailed information regarding unusual or unexpected aspects</td>
<td>- Participants may have issues developing rapport with researcher, impeding questioning.</td>
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<td>- Researcher has firsthand experience with the participant(s)</td>
<td>- Accuracy of reporting relies on the recording skills of the researcher</td>
</tr>
<tr>
<td>Qualitative Audio-Visual Research</td>
<td>Involves the collection of qualitative data, such as photographs, art objects, film, music, video games, websites, social media text, audio recordings etc. Analysed using various qualitative methods.</td>
<td>- An unobtrusive means of collecting data</td>
<td>- Difficult to interpret</td>
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<tr>
<td></td>
<td></td>
<td>- Accuracy of data collection</td>
<td>- The presence of an observer may be intrusive i.e. when taking photographs.</td>
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<td></td>
<td>- Allows participants to directly share their reality</td>
<td>- May be difficult to access</td>
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<td>- Not all information can be used in a final report, as text and image data are dense and rich.</td>
</tr>
<tr>
<td>Qualitative Documentation</td>
<td>The investigator collects public and private documents, such as newspapers, reports, journals, emails etc. Analysed using qualitative critical analysis methods.</td>
<td>- Can often be accessed at a time suitable to the researcher</td>
<td>- Accuracy and authenticity needs to be confirmed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Does not need to be transcribed, saving time.</td>
<td>- Articulation is subject to the author</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Accurate collection of participant’s views, in their own language and words.</td>
<td>- Like audio visual materials, information can be dense and difficult to analyse.</td>
</tr>
</tbody>
</table>
Based on this analysis, it was determined that an Action Research method, as a framework for the transformative mixed methods methodology, was best suited for the research. This choice was made in accordance to Creswell’s (2003) three influential factors when deciding on a research strategy:

1. the research questions/ problem;
2. the underlying methodology of research; and
3. the researchers’ theoretical perspective.

The justification for choice of research questions was discussed previously, both in the overview for this chapter (p. 91) and in the literature review (p. 87). These questions are:

*Primary Research Question:* How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?

*Sub Research Question 1.1:* What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?

*Sub Research Question 1.2:* What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?

These questions were formulated with the aim of improving the inclusiveness of a marginalised group, which is a core principle of the transformative mixed methods methodology (Mertens, 2003, cited in Creswell, 2003, pp. 136-138). Action research has origins in the mixed methods methodology, and shares characteristics and compatibilities including a pragmatic philosophical foundation and social justice perspectives, aligning with the underlying methodology for the research and researcher’s theoretical perspective.
To further justify the selection of an action research method, it was previously established that the research was exploratory in nature. This required flexibility, and a stepwise approach with action, critical reflection and revision. Action Research involves systematic enquiry and is an “open-ended research project that takes shape ‘under construction’” (Almekinders, Beukema, & Tromp, 2008, p. 23). In addition, it is a “continuous learning process in which the researcher learns and also shares the newly generated knowledge with those who may benefit from it” (Koshy, Koshy, & Waterman, 2011, "Definitions of Action Research", para. 3). The development of knowledge (or understanding) is the criteria for success and is considered instrumental to the process of action (or change). The change of the situation underlying the study is a potential result (Koshy et al., 2011).

While the exact origin of action research is unknown, and believed to have been utilised since the beginning of the 20th century, German psychologist Kurt Lewin is credited as having coined the terminology in 1946 (Ivankova, 2014). Lewin was concerned that traditional approaches to research did not assist in identifying solutions to critical social problems. Action research was conceived as a result, by “combining theory generation with changing a social system as a result of the researcher ‘acting’ within it” (DeLuca, 2008, p. 49).

Recent action research has been primarily associated with educational research, utilised in teaching and learning. The method has been used to describe and explain classroom practices, giving “prominence to the concept of ‘teacher as researcher’” (Stenhouse, 1975 cited in McNiff, Whitehead, & Laidlaw, 1992, p. 27). Action research is also a transferrable research method across other fields of studies (McNiff et al. (1992). It has gained its popularity in many fields including health care, nursing, social work, organisational development, and criminology (Ivankova, 2014).
As a result, various approaches to the implementation of action research have emerged, resulting in numerous documented models and definitions (Ivankova, 2014). For example, action research is often “associated with a constructivist worldview, because of its exploratory nature and reliance on qualitative methods” (p.89). However, as previously discussed, action research has an underlying pragmatic philosophical foundation, and association with a mixed methods methodology. While differences in action research approaches do exist across disciplines, the core models share a general framework.

Action research is often depicted as a spiral or cyclical approach consisting of several stages. An example is the Four-Stage Action Research Model, as in Figure 13, which was first proposed by Lewin (1948b, cited in Ivankova, 2014). It is a cyclic process consisting of four stages:

- **observe**, which is the identification of a problem;
- **reflect**, where critical reflection is conducted, to identify existing knowledge and potential solutions;
- **plan**, which involves developing a procedure to address the given problem; and
- **act**, where the action/change takes place.

Figure 13 Basic Four-Stage Action Research Model (based on Lewin, 1948b, cited in Ivankova, 2014)
The cyclic nature of the model encourages the repetition of a process until a solution to the problem is found (Ivankova, 2014) – promoting flexibility and responsiveness. Responsiveness is one of the key factors of action research allowing the research to respond to emerging information because of the cyclic process (Dick, 2000). Responsiveness also aids rigour in data collection by early cycles informing the later cycles. Various other action research models follow a similar cyclic process, with slight amendments to terminology or number of cycles (Davison, Martinsons, & Kock, 2004; Kemmis & McTaggart, 2007; Stringer, 2013; Whitehead, 1985). Once such example is the Look, Think and Act framework (Figure 13).

![Look, Think and Act Framework](image)

**Figure 14 Look, Think and Act Framework (Stringer, 2013)**

The Look, Think and Act framework (Figure 14) “enables people to commence their inquiries in a straightforward manner and build greater detail into procedures as the complexity increases” (Stringer, 2014, cited in Ivankova, 2014, p. 76). Each cycle consists of three stages, including:

- **look**, where the problem is identified and relevant information or data is collected. This aids in developing a complete picture of the problem, and in extending the researcher’s understanding;

- **think**, where the data collected during the look stage is analysed, interpreted and explained; and
• **act**, which involves using the results of findings in the think stage to inform future cycles, and to develop a plan for action.

While the terminologies, and number of stages, may differ between models the underlying principles of action research remain the same. Dick (2000) identifies these as being:

• **cyclic**, consisting of cycles which occur in sequence. Each cycle informs the next to aid in making progress towards research outcomes;

• **participatory**, as the research method frequently involves participation, with participants becoming co-researchers and informants. However, participation may also refer the researcher being the only active participant;

• **qualitative**, as contemporary action research is frequently conducted in field settings to evaluate practice. Because of this, qualitative methods are often used to facilitate flexibility and responsiveness. However, as a framework based on mixed methods, action research permits the use of both qualitative and quantitative methods; and

• **reflective**, as a crucial process of each cycle involves critical reflection of the process and outcomes, which informs future cycles.

For this research, the Look, Think and Act framework was adopted. This choice was made due to the model’s applicability as the research framework because of its flexibility, and succinctness and use in non-participatory driven action research. Further, each cycle may result in an overlap between the Act of one cycle to the Look stage of a subsequent cycle, framing new information that may lead to future inquiry. The action research method, and discussion on how it informed the research process, is described in further detail in section 3.4.
3.4 Action Research Method

Section 3.3 described the choice of a transformative mixed methods methodology for this research aligning with investigation of main and two subsidiary research questions. The application of a cyclic process based on an action research method was discussed (Ivankova, 2014). This section describes how the cyclic process of look-think-act was used as a framework of collecting data, which is depicted in Figure 15.

![Figure 15 Application of the Look, Think, and Act framework in this research](image)

The underlying process of action research (Figure 15) is the incremental approach through iterative cyclic process to build knowledge based upon information gained in each cycle; and subsequent cycles are informed by the previous. The qualitative results in the first cycle, and qualitative and quantitative results in the second cycle, were triangulated to act on the third cycle. This is in-line with the transformative mixed methods methodology, where both sequential and concurrent methods may be employed at the investigators discretion.

Three cycles were involved in the iterative process of this research. The first two cycles were designed to answer the two subsidiary questions:
Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?

Sub Research Question 1.2: What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?

It was intended that the results of first two cycles would inform the final cycle answering the primary research question:

Primary Research Question: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?

Each cycle included three stages of data collection and analysis:

- **look**, to gather information and resources;
- **think**, where the data collected during the look stage was analysed, interpreted and explained; and
- **act**, including critical reflection and planning for future cycles, and working towards a solution to the problem.
3.4.1 Cycle 1: Analysis of game design methods

Cycle 1 of the study (Figure 16) investigated the relationships between current game design practices identified in the literature review. This included developing an understanding of the relationships between predictive and adaptive approaches. By identifying potential relationships, a means of facilitating accessible design for the various approaches was identified. The process included the following steps:

1. **Look**: the data collected in the literature review served as the first stage for this cycle. Results of the critical analysis informed the research questions and development of understanding of the research problem.

2. **Think**: analysis and interpretation of the results from the *Look* stage to identify relationships between the different approaches to video game development. This included a visual depiction of the current approaches to video game design in diagrammatic format to assist in analysis and interpretation.

3. **Act**: critical reflection of results from the *Think* stage were used to answer research question 1.1., and inform future cycles.
3.4.2 Cycle 2: Analysis of sound typologies and visual feedback

Cycle 2 (Figure 17) determined a means of identifying and classifying the forms of audio and visual feedback used in video games. Critical analysis of academic studies and industry guidelines in the literature review determined that visual feedback elements are commonly recommended as an alternative to audio to foster hearing accessibility. However, those sources were found to lack specificity, and provided limited guidance on how to identify or implement suitable alternative forms of visual feedback for specific audio types. These findings informed the formation of the second subsidiary research question and this research cycle, which involved an analysis of literature and observations of video games to identify and classify the forms of audio and visual feedback used in video games.

In addition, subtitles and closed captions were found to be a commonly cited means of inclusive game design for the DHH. However, data on the usage and opinions of the textual form of feedback were found to be limited. One of the key characteristics of action research is the participatory nature. A survey was planned for the second cycle with local game developers, the general video game
community, and gamers through online communities who are DHH. Results of the survey were used to:

- identify forms of feedback not identified during the analysis of literature;
- determine use and opinions of feedback types including subtitles and closed captions; and
- support findings in the first qualitative data collection stage of this cycle.

One of the key characteristics of action research is the emergent nature of data informing and affecting the subsequent data being collected. It was unknown what the survey questions would consist of prior to commencement of the research. The questions were developed during the second cycle, based on findings of the qualitative data collection in the first stage of Cycle 2 (Figure 17). The survey questions designed as an output of Cycle 2 are described in Appendix C.

The use of two methods adheres to the chosen transformative mixed methods methodology. The process is depicted in Figure 18, and included:
Qualitative data collection and analysis:

1. **Look- Literature Review**: an extended and critical analysis of previous studies found in the literature related to identifying video game sound and visual feedback types, and methods of classifying those elements.

2. **Think- Analysis**: An analysis of the findings from 1 Look to:
   - determine whether existing methods of classifying feedback elements existed for visual and audio feedback in video games; and
   - determine the practicality, usage and quality of implementation of subtitles and closed captions in video games.

Concurrent qualitative and quantitative data collection and analysis:

3. **Look- Survey**: collect data from a survey to determine usage and opinions of implementation of alternative forms of feedback used in video games. This process included:
   - development of a survey based on results from step 2 Think (See Appendix C)
   - conducting surveys with local game developers, and members of the video game community (including DHH gamers).

4. **Think- Analysis**: an analysis of the findings from 3 Look to:
   - identify additional visual and audio-visual feedback elements that may not have been identified in 2 Think;
   - determine the practicality, usage and quality of implementation of subtitles and closed captions in video games.

5. **Triangulation of results**
   - **Act**: triangulation of the results during interpretation, using results from steps 1-4. Results were used to determine how to classify different visual and game sound feedback types.
and determine how visual feedback may be utilised to substitute sound. The results of this stage would be used to answer the second subsidiary research question.

3.4.3 Cycle 3: Development of potential solution

Consistent with the use of the action research method, given the nature of the investigation, exact details of Cycle 3 were unknown. However, it was expected that the results of the previous two cycles would inform a potential solution and response to the primary research question. The stages for Cycle 3 were predicted to include:

1. **Look**: gather the results from Cycle 1 and 2.

2. **Think**:
   - analyse the data from 1. *Look*;
   - interpret the data to determine whether a solution could be derived; and
   - explain how the potential solution would address the primary research question.

3. **Act**: plan a solution based on the findings of the *Think* stage along with critical reflection and recommendations for implementation and use. Findings of this stage were used to answer the primary research question.
The detailed process for Cycle 3 is explained in Chapter 6, including description of the iterative development of the final solution.

### 3.5 Data Collection and Analysis Methods

Section 3.3 described the underlying transformative mixed methods methodology chosen for this research. As discussed in section 3.4, the research was designed with action research as the framework employing an iterative cyclic process to address the research questions. Each cycle consisted of qualitative and/or quantitative data collection methods in the *Look* stages. In turn, this required different approaches to analysis of the data in the *Think* stages. This section describes the data collection and analysis procedures employed, including:

- **3.5.1 Qualitative data collection and analysis method**
- **3.5.2 Quantitative data collection and analysis method**
- **3.5.3 Survey design, including question design, sampling methods, and procedure**
- **3.5.4 Materials and software used**
- **3.5.5 Ethical considerations of the study**

#### 3.5.1 Qualitative data collection and analysis method

Qualitative data in this research was intended to consist of forms of textual information, including literature, audio visual materials, and survey responses. Creswell (2013) believes that such data is often dense with information, some of which is superfluous to the area of study. As a result, data needs to undergo 'winnowing', which is the process of syphoning through data to identify relative information and disregarding other parts. Relevant information is then further analysed, categorised and interpreted. As this research employed a cyclic Action Research method, a detailed description of the qualitative data collection and analysis methods is included in Chapters 4-6. This section provides a
description of the qualitative methods used for each cycle, which informed the evolving research design.

![Figure 20 Qualitative data analysis process for this research based on Creswell (2003)](image)

This process is represented in Figure 20, based on Creswell (2003) six steps of qualitative data analysis and interpretation. The general steps have been blended with the specific action research design stages:

- **Look**:
  - Step 1: Data is collected from sources, organised and prepared for analysis in the *Think* stage. Organisation includes sorting, transcription, and storage.

- **Think**:
  - Step 2: critical analysis of the data to obtain an *understanding* of the underlying themes and tones of the text.
  - Step 3: Information is thematically organised on topics and ideas. May also include a diagrammatic depiction to show interrelationships.
  - Step 4: A brief description of the identified information, usually based on the coded themes or categories.
Step 5: Information identified in steps 3 and 4 is described in further detail to convey the findings of the analysis. This may also involve the use of tables or diagrams to convey descriptive information.

- **Act:**
  
  Step 6: Interpreting the findings, to influence future cycles and plan for action or change.

In addition to the above steps, Creswell (2003) suggested that steps should be taken to ensure accuracy and reliability when using qualitative research. Steps that were used for this research included:

- rich and thick descriptions to convey findings;
- using member-checking, which is the process of determining the accuracy of qualitative findings by presenting findings to participants to determine accuracy through feedback; and
- triangulation of data sources to build coherent justification (p. 196).

The survey used a form of member-checking by questioning participants on their understanding and opinions of hearing accessibility considerations in video games. Questions were based on qualitative findings in the second cycle (see Appendix C). Triangulation of the sources of data occurred during interpretation in the **Act** stage of Cycle 2 and informed the third cycle of the research. Member-checking was not used for Cycle 3, as it was not required.
3.5.2 Quantitative data collection and analysis method

Quantitative data in this research was collected as part of a survey in the second cycle (See section 5.7). The self-administered survey included both qualitative and quantitative questions, to gauge participant opinions and use of specific feedback types (See Appendix C). The quantitative analysis process for the survey (See section 5.8) was based on Creswell’s (2003) quantitative survey data analysis procedure (Figure 21) blended with the action research stages.

![Survey data analysis process for this research (adapted from Creswell (2003))](Figure 21)

The process was:

- **Look:**
  - Step 1: Data was collected from instruments, coded, and stored. The data included reports generated by the Qualtrics survey software. Analysis files were generated within the software, based on queries, such as relating variables and comparing responses.

- **Think:**
  - Step 2: Information regarding the number of respondents / non-respondents was provided (See section 5.8.1). This information was presented in table format, and included information regarding response bias.
Step 3: Tabulation and cross-tabulation of data, and a descriptive analysis of results was provided (See sections 5.8.2-5.8.4). This included means, averages, range of scores etc. Findings were derived, and any inconsistencies or anomalies explained.

- Act:

  Step 4: The results were interpreted, and used to influence future cycles and plan for action or change (See section 5.8.4 and 5.9).

3.5.3 Survey Design

A survey was conducted as part of Cycle 2 of the data collection. The survey took the form of a cross-sectional self-administered survey to gather both qualitative and quantitative data. The process of collecting and analysing the survey data has been previously discussed (see 3.5.1 and 3.5.2), and explained in greater detail in Section 5.8. This section explains how the surveys were designed.

The purpose of the survey was to aid in determining what alternative forms of feedback have been used in video games as an alternative to audio. In addition, the survey determined participants’ opinions on the implementation and use of subtitles and closed captions in video games. A survey was chosen as the data collection procedure due to:

- the rapid turnaround for data collection;
- the potential for identifying the opinions and beliefs of a large population from a small sample size; and
- to support the accuracy and reliability of findings Cycle 2 through triangulation and member-checking (Creswell, 2003).
The survey used questions based on qualitative findings in Cycle 2. As a result, it was unknown what questions would be used in the survey design prior to the commencement of the research. The survey design is presented in Appendix C, and based on “A Checklist of Questions for Designing a Survey Method” (Creswell, 2003, p. 155). The checklist provided a guide to the development of surveys, including: survey sampling method; question structure; and instrumentation.

The selection of participants for the survey was based on snowball sampling. The purposive non-probability sampling technique was chosen due to its usefulness in locating and accessing individual participants who may be otherwise inaccessible or hard to find. This included recruiting from specific predefined groups via online social networking services, such as LinkedIn, Facebook and Twitter, and asking participants to ‘share’ the survey with others from their specific communities. Participants were expected to include both male and female participants, of varying ages, including:

- members of the DHH community, such as:
  - adults who are DHH
  - DHH children, with permission from parents/guardians
- parents and family members of children who are DHH; and
- video game developers.

The specific online community groups were selected for recruitment were:

- Deaf PC gamers;
- Deaf Gamer’s Network;
- Deaf Gamer Station;
- Deaf Xbox Gamers;
- New Zealand and Australia gaming community; and
• Parents of Hearing Impaired Children.

In addition, to engage with local industry professionals, such as game developers, local organisations were called upon to aid in recruitment through social networking channels. An example includes Let’s Make Games, which is a game development community based in Perth, Western Australia.

The sample size of a quantitative survey is determined based on a sample size formula according to a predetermined population size to provide an accurate statistical representation of the target demographic (Creswell, 2003). However, a predefined population size for the survey was not required as the survey gathered qualitative feedback and was not statistical.

3.5.3.1 Question structure and instrumentation

As previously mentioned, the questions for the survey were unknown prior to the commencement of the research. This was due to the questions being informed by the results of the qualitative data collection in Cycle 2. The questions developed as part of Cycle 2 are discussed in Chapter 5 and given in Appendix C.

The instrumentation for the survey was considered crucial to ensure validity and reliability, ease of distribution, and reporting of results. It was for this reason that Qualtrics survey software was selected. The survey software was provided by Edith Cowan University to all Postgraduate Research Students, and is described in greater detail in section 3.5.4.
3.5.4 Materials and software

The following materials and resources were used for this research:

**EndNote**

The EndNote software package was used for the management of literature, digital media and other resources utilised in research. The software provided the ability to search online databases for relevant information, and for storing and categorising information in a local database library for ease of access. ("EndNote product details," 2016).

**Qualtrics survey software**

The Qualtrics survey software facilitates the development, distribution, data collection and analysis of surveys. The Qualtrics survey software is provided by Edith Cowan University for research students providing training in use of the software ("Qualtrics," n.d.). The Qualtrics software was used for the surveys conducted during the data collection process in Cycle 2.

**Hardware for audio-visual material**

As part of the third research cycle, various video games were analysed to identify forms of feedback. The hardware used for these games included:

- Xbox 360 Console
- Xbox One Console
- PlayStation 4 Console
- PlayStation 3 Console
- Samsung 42” LCD television
- 2014 MacBook Pro 15”, 512GB Hard Drive, 16GB RAM, and a dual-boot setup, including:
  - OSX El Capitan Operating System; and
  - Microsoft Windows 10
### Video games

The video games analysed in the third cycle of this research included:

Table 7 Video games analysed as part of Cycle 2, Iteration 2

<table>
<thead>
<tr>
<th>Game Title</th>
<th>Platform</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioShock Infinite</td>
<td>Xbox 360</td>
<td>(Irrational Games, 2013)</td>
</tr>
<tr>
<td>Dead Space 2</td>
<td>Xbox 360</td>
<td>(Visceral Games, 2011)</td>
</tr>
<tr>
<td>Diablo III</td>
<td>Xbox 360</td>
<td>(Blizzard Entertainment, 2012)</td>
</tr>
<tr>
<td>Fable III</td>
<td>Xbox 360</td>
<td>(Lionhead Studios, 2010)</td>
</tr>
<tr>
<td>Fallout 4</td>
<td>Xbox One</td>
<td>(Bethesda Game Studios, 2015)</td>
</tr>
<tr>
<td>Gear of War III</td>
<td>Xbox 360</td>
<td>(Epic Games, 2011)</td>
</tr>
<tr>
<td>Halo 4</td>
<td>Xbox 360</td>
<td>(343 Industries, 2012)</td>
</tr>
<tr>
<td>L.A. Noire</td>
<td>Xbox 360</td>
<td>(Team Bondi, 2011)</td>
</tr>
<tr>
<td>Metal Gear Solid V: The Phantom</td>
<td>PlayStation 4</td>
<td>(Kojima Productions, 2015)</td>
</tr>
<tr>
<td>Minecraft</td>
<td>Windows 10</td>
<td>(Mojang, 2011)</td>
</tr>
<tr>
<td>No Man’s Sky</td>
<td>PlayStation 4</td>
<td>(Hello Games, 2016)</td>
</tr>
<tr>
<td>Rise of the Tomb Raider</td>
<td>Xbox One</td>
<td>(Crystal Dynamics, 2013)</td>
</tr>
<tr>
<td>Stranded Deep</td>
<td>Windows 10</td>
<td>(Beam Team Pty Ltd, 2015)</td>
</tr>
<tr>
<td>Super Mario Bros.</td>
<td>Nintendo</td>
<td>(Nintendo, 1987)</td>
</tr>
<tr>
<td>The Elder Scrolls V: Skyrim</td>
<td>Xbox 360</td>
<td>(Bethesda Game Studios, 2011)</td>
</tr>
<tr>
<td>Team Fortress 2</td>
<td>Windows 10</td>
<td>(Valve Corporation, 2007)</td>
</tr>
<tr>
<td>The Last of Us</td>
<td>PlayStation 3</td>
<td>(Naughty Dog, 2013)</td>
</tr>
<tr>
<td>The Order: 1886</td>
<td>PlayStation 4</td>
<td>(Ready at Dawn, 2015)</td>
</tr>
<tr>
<td>Titanfall</td>
<td>Xbox One</td>
<td>(Respawn Entertainment, 2014)</td>
</tr>
<tr>
<td>Wolfenstein: The New Order</td>
<td>Xbox One</td>
<td>(MachineGames, 2014)</td>
</tr>
</tbody>
</table>
3.5.5 Ethical Considerations

Prior to commencement of data collection, the survey used in Cycle 2 was first reviewed by the Edith Cowan University Human Research Ethics Committee, and received approval in accordance to guidelines contained in legislation and policies. Ethical considerations for this research included:

- voluntary participation in surveys, with all participants required to sign a letter of consent (Appendix B) or agree to the terms of the survey via a digital letter of consent (Appendix D);
- participants provided an information letter (Appendix A) regarding the purpose of the research, and their role;
- participants assured of their confidentiality and protection of privacy. No identifiable information was intentionally collected in the surveys. On review of the survey data, any identifiable information was removed from the results to maintain confidentiality and protection of the participant’s privacy;
- participants advised that their responses could not be withdrawn after completion. This was due to the submitted surveys containing no identifiable information. As a result, completed surveys could not be distinguished from other responses to be removed; and
- data storage considerations, which included storage of all responses on the Edith Cowan University Qualtrics server. This information was downloaded and stored on a local workstation, which was password protected and removed once analysis was completed.
3.6 Limitations of the research methods

This section describes the limitations of the research methods.

Action Research

On selection of the action research method, and analysis of strengths and limitations, several potential issues were identified. These have been addressed as follows:

- **Target group:** to ensure the scope of research was achievable within the time frame for doctorate research, the intended outcome target group was constrained. For example, children who suffer from hearing loss may also experience cognitive or physical impairment. To address this issue, areas of accessibility other than hearing impairment were omitted from this research.

- **Non-generalisable results:** a common perception of action research is that the results are non-generalisable. This is primarily due to Action Research (Dick & Swepson, 2013):
  - being commonly employed for the evaluation of an investigator’s professional practice or the study of social sciences;
  - not usually employed to address precise research questions, which are typically associated with experimental research; and
  - not seeking to determine relationships between variables, due to external variables in the field being uncontrollable or too complex to investigate.

However, this research was not aimed at evaluating professional practice, nor was the research a scientific study of human society or social relationships. Instead, action research was used as a process to provide a stepwise approach to action, critical analysis and reflection. In addition, the research questions for this research were based on findings of previous academic research.
These questions were precise, specific to the research problem identified, and aimed to provide explicit outcomes.

While the research process was not experimental, it aimed to investigate the relationships between variables. This was possible as the research was not conducted in the field, and primarily involved the critical analysis of literature and observations of video games where identification formed part of the research process. For example:

- In Cycle 1, the approaches to video game design and accessible design were variables. The cycle aimed to identify the relationships between the variables, to identify a generalisable approach to facilitating accessible game design.

- Cycle 2 classified audio and visual feedback elements as independent variables. The aim of the cycle was to identify the relationship between the variables and determine what visual feedback elements may be used to complement audio feedback.

- Validity as research: There has been some criticism regarding bias towards the data gathering and analysis by the researcher in action research, due to their innate interest in the research. The researcher stayed objective throughout the research process, and did not apply personal biases to the data analysis or interpretation. Further, to demonstrate rigour of the study, the research used thick detailed descriptions of the data collection and analysis. Member-checking was also employed using surveys with participants. Finally, data from both qualitative and quantitative sources were used for triangulation to build coherent justification of findings.
3.7 Chapter summary

This chapter has described the reasoning and underlying choices for the design of this research. This included the choice and justification for a transformative mixed-methods methodology, and the Look, Think, Act Action Research framework. As part of the action research framework, three cycles were introduced to address each of the research questions:

- Cycle 1: investigate the relationships between the approaches to video game and accessible design, to identify a means of facilitating accessible design for the deaf and hard of hearing.
- Cycle 2: determine a means of classifying and identifying the forms of visual and auditory feedback used in video games.
- Cycle 3: Results of the first two cycles used for triangulation, to aid in the identification and development of a means of facilitating accessible video game design.

Each of these cycles are discussed at length in Chapters 4-6.
Chapter 4: Cycle 1 – Analysis of Game Design Methods

Cycle 1 (Figure 22) investigated the relationships between current game design methods identified in the literature review. This included defining and characterising the relationships between predictive and adaptive methods. Results of the analysis were combined with the new video game classification model developed by the researcher as part of the research through the literature review (Figure 4). Lastly, the approaches to accessible design were integrated in a final model, to determine a potential solution to research question 1.1:

Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?

Chapter 4 is presented as follows:

- **Look**: a summary and organisation of literature and findings of the critical analysis presented in the literature review. This included current issues for video game classification, game design methods and accessibility considerations;

- **Think**: critical analysis of findings, with diagrammatic depictions of game design methods and accessible game design approaches.
• **Act**: reflection of findings from the Think stage, interpretation of results, development of the new video game classification model, response to research question 1.1, and planning for future cycles.

### 4.1 Look

The data collected in the literature review identified the research problem, informed the research questions, and informed the *Look* stage for this cycle. On commencement of the literature review, it became apparent that there was no standardised definition or classification for the terminology ‘serious games’. Further investigation determined that the issue extended to other forms of video game or game-like software including simulations, virtual worlds, and pure entertainment games (see 2.7).

This highlighted a potential issue with identifying the methods of video game design for this research. Because of these findings, a new classification model was proposed (see 2.7.2). Using this new classification model, video game design methods were identified in section 2.8. In addition, approaches to accessible game design were investigated in section 2.9. As this cycle was predominantly literature based, the content in Chapter 2 formed part of Cycle 1 of this research. Findings of the literature review are organised and presented in Table 8, which served to inform the Think stage of this cycle.

<table>
<thead>
<tr>
<th>Game design method</th>
<th>Description</th>
<th>Accessibility considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictive</td>
<td>Requires comprehensive planning and documentation prior to commencement of development. Uses a structured framework for design, including Instructional Design models, General Information Systems models, and Game Design Frameworks.</td>
<td></td>
</tr>
<tr>
<td>Instructional design model</td>
<td>Not specific to game design or design of interactive digital media. The models lack game design principles, and may be used in conjunction with additional design methods, such as game design frameworks.</td>
<td>• No evidence found of accessibility considerations integrated to IDMs. • May employ external solutions, such as accessibility guidelines at discretion of developer.</td>
</tr>
</tbody>
</table>
• General information systems model
Not specific to game design. These types of development models are often used in software development, and lack core game design principles.

• Game design framework
Frameworks designed specifically to assist in game design. Typically consist of several stages, to guide development from concept to creation. May be:
1. General- appealing to a wide demographic, without consideration for needs or a specific target audience.
2. Targeted- developed for a specific target audience

• No evidence found of accessibility considerations as part of a GIS.
• May employ external accessibility solutions, such as guidelines, at discretion of individual developer.

Adaptive (freeform/iterative design)
An alternative approach to game design, typically employed by independent developers. Requires little planning, and is an iterative process of prototyping, testing, and revision.

• Do not typically include accessibility considerations as an explicit stage of development.
• Some frameworks may include consideration for a specific target audience, with testing of user base to determine usability and may account for some level of accessibility.
• May employ external accessibility solutions, such as accessibility guidelines, at the discretion of an individual developer.

Game assessment frameworks
Not used for the development of video games from concept to creation. Typically used during a stage of development, or after development, to evaluate a specific characteristic of video games.

• No preplanning to account for accessibility considerations.
• May employ external solutions, such as accessibility guidelines, during development.
• Due to iterative design, a user-centred approach may involve feedback during testing phase with a specific target audience and account for some level of accessibility.

• No evidence found to support use of a game assessment framework for accessible game design.

4.2 Think
The Think stage of Cycle 1 identified relationships between the video game design methods, types of video games, and approaches to accessible design. These are introduced and discussed in detail in the following sub-sections:

• Game design methods and interrelationships: Presents a model of current game design methods, and the relationships between each method.
• **Mapping game design methods to video games:** Presents a mapping of game design methods, identified in the *Look* stage, to specific forms of video games identified in the new video game classification model (Figure 4).

• **Game design methods and accessibility considerations:** Presents a model used to determine how different game design methods implement accessible design.

### 4.2.1 Game design methods and interrelationships

Figure 23 conveys findings of critical analysis, conducted in the literature review, relating to the video game design methods. The diagram also identifies connections between those methods.

![Figure 23 Model of Game Design Methods](image)

(A) Game Design Methods may be (B) Predictive or (C) Adaptive. Predictive design follows traditional design methods, with a documented and formalised design strategy. Documentation occurs prior to development, and guides the development process. Current methods of predictive game design may
utilise (D) Generalised Information Systems models; (E) Instructional Design Models; or (F) Game Design Frameworks.

However, as identified in the literature review and summarised in the Look stage, both (D) Generalised Information Systems Models and (E) Instructional Design Models lack core game design principles. These methods are typically not suited for comprehensive game design. In contrast, (F) Game Design Frameworks are those which are explicitly used for game design, and may be:

- (G) Targeted, which involves identification of a specific target audience and their needs during a stage of design; or
- (H) Generalisable, which provides focus on how to elicit an expected generalised emotional response, rather than an individual user’s experience.

Further, while (E) Instructional Design Models may be used for serious game development, video games are a method of delivery. Instructional Design Models often require the addition of an (F) Game Design Framework to assist in designing the gaming component. Similarly, a (F) Game Design Framework may utilise an (E) Instructional Design Model to aid in developing content suitable for education and training. However, Game Design Frameworks which are specifically tailored to the development of serious games for education and training were identified. These types of Game Design Frameworks did not require the addition of an Instructional Design Model.

Adaptive Design (C) is an alternative approach to video game design, typically employed by independent developers. These independent developers frequently forgo financial backing, support, and control from more traditional sources such as publishers. This independence has resulted in increased creative freedom, with some independent developers employing the alternative design
strategy of (I) Freeform development. Freeform development is experimental, involves minimal pre-planning, and includes rapid prototyping followed by testing and revision.

Finally, (J) game assessment frameworks are supplementary. These frameworks are used to facilitate the analysis of existing video games or aid developers in a specific stage of the game design process. For example, play-testing may be included as part of a game assessment framework, and can be employed in (G) Targeted, (H) Generalisable, or (I) Freeform development.

4.2.3 Mapping game design methods to video games

Figure 24 is based on the new video game classification model developed in the literature review (2.7.2) and the new model of game design methods (Figure 23). This diagram visualises how game design methods relate to forms of video game software. It is important to note that it is a generalisation of the current state of video game design, and there may be exceptions where specific types of video games or game-like software are developed via alternate means.

From the outcomes of this cycle the analysis indicates that (A) adaptive approaches are typically employed for non-serious games, such as virtual/micro worlds and purely entertainment games. (B) Predictive design approaches encompass the entire spectrum, and consists of frameworks such as (C) Information Systems models, (D) Instructional Design models, and (E) Game Design Frameworks.
(C) Information Systems (IS) models are typically used for software development, including simulations. Neither IS models or simulations include core game mechanics. Similarly, (D) Instructional Design models (IDM) do not include core game mechanics. Video games are a method of delivery, and IDMs do not provide any guidance on the design or development of video games. However, IDMs may be used for either purposeful or adapted serious game design when used in conjunction with a (E) Game Design Framework.

A (E) Game Design Framework may be either (F) Targeted or (G) Generalisable. Targeted frameworks are those which include the identification and consideration of a specific target audience.
These frameworks are applicable to the development of all video games on the spectrum between purposeful serious games and purely entertainment games. Generalisable game design frameworks, however, do not include consideration for a specific target audience. These frameworks are intended to evoke expected emotional responses from a wide demographic, and only applicable to games on the spectrum between virtual/micro worlds and purely entertainment games.

Finally, (H) game assessment frameworks are applicable across the entire video game spectrum. These frameworks are not used for the design and development of games from concept to creation. Instead, a game assessment framework is designed for the explicit purpose of facilitating the assessment of a characteristic of a game either during or after game design and development.

### 4.2.3 Game design methods and accessibility considerations

Using the model of game design methods (Figure 23), and the findings for the different approaches to accessible design in the *Look* stage of this cycle, a new model to represent the relationships between design approaches and accessible design methods was developed (Figure 25). This model organises the approaches to accessible game design, and demonstrates the connection between each game design method. The purpose of this model was to determine what methods for guiding accessible design for the DHH may be best suited as a potential solution for the identified research problem.

As identified in the *Look* stage, few forms of (B) Predictive or (C) Adaptive design explicitly employ accessible approaches to video game design as part of the core game design process. Those that do, may utilise (K) iterative design or other (L) external sources.
Targeted approaches (E) are user-centered, identifying a specific target audience or demographic during the design process. These frameworks are frequently iterative, involving (K) testing, review and revision at all stages of design and development. Similarly, (I) freeform development is an experimental method of game design, involving rapid prototyping through (K) iteration. As part of the iterative design process, (L) external sources may be used to guide development. These external sources include:

- (M) user feedback, throughout development to determine if the game design meets the requirements of the target audience;
- (N) accessibility guidelines to aid with identification of potential accessibility solutions for the intended target audience; and
• (O) accessibility experts to assist with developing inclusion strategies for the intended target audience.

Conversely, (H) generalisable design methods are not user-centered. These game design methods do not provide focus on user-experience design for a specific target audience. Instead, a generalisable approach to design is primarily interested in eliciting generalisable emotional responses from the end user. However, a (G) generalisable approach may also employ (L) external sources to guide accessible design, such as (N) accessibility guidelines and (O) accessibility experts.

In the literature review, it was also determined that select few seasoned developers, who typically employ a generalisable approach, may also take a non-standardised approach to accessible design. This approach included engaging with users, representative of a minority group, to obtain (M) feedback during the development process. However, developers who have implemented this process believe it is non-standard and an uncommon practice (M. Laidlaw, personal communication, 2015; Y. Bernier, personal communication, 2016).

4.3 Act

From the analysis in the Think stage of this cycle, game design methods and interrelationships were identified (Figure 23). In addition, the individual game design methods were mapped to the different types of video game software in the new video game classification (Figure 24). Finally, accessible design approaches were modelled to determine the relationships with the different game design methods (Figure 25).
The results of the *Think* stage determined that several solutions to facilitate the accessible design of video games exist. As part of this *Act* stage, the findings were interpreted, with limitations and strengths for each described in Table 9. The results of the findings in this stage were used to identify a suitable means of facilitating accessible design for the different game design methods, and aided in identifying a response to research question 1.1.

Table 9 Limitations and strengths of potential solutions

<table>
<thead>
<tr>
<th>Solution</th>
<th>Limitation of Solution</th>
<th>Strength of Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game Design Framework</td>
<td>• Only applicable to predictive design methods.</td>
<td>• Useful for providing guidance on developing a video game</td>
</tr>
<tr>
<td></td>
<td>• Require a targeted approach, as generalised methods do not identify a specific target audience.</td>
<td>• Industry standard for mainstream video game development.</td>
</tr>
<tr>
<td></td>
<td>• Game design frameworks are varied, and there isn’t a standardised ‘one-size-fits-all’ framework.</td>
<td>• Used in academia and in educating student and novice developers.</td>
</tr>
<tr>
<td>Accessibility Guidelines</td>
<td>• Lack specificity for hearing impairment, resulting in a gap for additional solutions.</td>
<td>• Provides a background of issues that may be encountered</td>
</tr>
<tr>
<td></td>
<td>• Explain what can be done, not the technical ways of how to implement hearing accessibility.</td>
<td>• Provides general solutions to certain accessibility considerations</td>
</tr>
<tr>
<td></td>
<td>• May be difficult to specify the technical ways of implementation, due to the various forms of video games, and ever evolving nature of the medium.</td>
<td></td>
</tr>
<tr>
<td>User-feedback</td>
<td>• Requires developer to be proactive, seeking participants from a specific demographic.</td>
<td>• Feedback from participants from the intended target audience will be able to identify limitations of the accessible design.</td>
</tr>
<tr>
<td></td>
<td>• Can be time consuming</td>
<td></td>
</tr>
<tr>
<td>Trained Accessibility Experts</td>
<td>• May be costly, both financially and time wise, for training.</td>
<td>• Able to provide expert knowledge and experience to identify potential accessibility issues, and solutions unique to the game.</td>
</tr>
<tr>
<td></td>
<td>• Independent developers and small studios may not have the funding available to employ a trained expert.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• May require multiple consultations throughout stages of development.</td>
<td></td>
</tr>
<tr>
<td>Game assessment framework</td>
<td>• A game assessment framework for accessibility has not previously been explored.</td>
<td>• Can be used in both predictive and adaptive approaches to game design.</td>
</tr>
</tbody>
</table>
The analysis of the strengths and limitations of potential accessibility solutions for the research problem indicated that the practical solution was the use of a game assessment framework. A game assessment framework was found to have potential application across the entire video game spectrum and in all relevant game design methods. In addition, it was predicted that a game assessment framework may provide greater specificity than an approach using accessible game design guidelines.

To guide the development of the new game assessment framework, the following were used:

- existing accessibility guidelines;
- results of critical analysis of academic studies and literature from accessibility experts; and
- results of Cycle 2, including user-feedback as part of a survey in the second cycle.

The findings of this stage answered the first subsidiary research question, which was:

**Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?**

The research question can be answered in two parts. The first is in response to ‘what are the different approaches used for the design of video games?’. This is answered by the three independent diagrams, accompanied by rich and thick textual descriptions identified in the Think stage of this cycle. These included:

- A visual representation of current game design methods (Figure 23);
• Game design methods mapped to the forms of video game software (Figure 24); and
• The relationships between approaches to accessible design and game design methods (Figure 25)

The second half of this question was ‘how might these be amended to facilitate accessible design for the deaf and hard of hearing?’. This was answered in the Act stage of this cycle, with Table 9, which analysed the limitations and strengths of potential solutions. This part of sub-question 1.1 would be effectively addressed by creating a game assessment framework. Such a framework would be based on existing accessibility solutions and informed by subsequent research cycles.

Additional research was required as it was determined in the literature review that commonly employed accessibility solutions lacked specificity for the technical implementation of hearing accessibility solutions. This included accessibility guidelines that failed to identify suitable alternative visual user interface elements to specific types of audio feedback. Therefore, it was critical to develop an understanding of video game sound typologies and visual feedback elements in the next cycle of this research. This process is represented in Figure 26.

Figure 26 Process to develop a video game feedback model
It was proposed by developing an understanding and means of classifying (A) game sound topologies and (B) video game visual user interface elements a (C) video game feedback model could be developed. The video game feedback model was subsequently used to map specific visual feedback elements to categories of game sound. Findings would then be used to aid in the development of the new game assessment framework. In turn, this solution could potentially be utilised by developers for identifying alternatives to game sound, improving accessible game design for the deaf and hard of hearing.
Chapter 5: Cycle 2 – Analysis of Sound Typologies and Visual Feedback in Video Games

Cycle 2 (Figure 27) of this research established an understanding of video game sound typologies and visual user interface elements. The results were used to aid in developing a model to represent how the two forms of feedback are interrelated. Consequently, it was apparent that specific visual elements could be utilised to substitute or complement categories of audio feedback in video games.

In addition, a survey was conducted with game developers, gamers, and parents of children who are deaf and hard of hearing (DHH). The survey was used for member-checking and to identify potential gaps in preliminary findings. The survey questions were designed based on the analysis on the different feedback types in the Think stage of the first two iterations of Cycle 2.

This section describes the three iterations of Cycle 2:

- **First Iteration:**
  - Identify the importance of individual sounds in games, and typologies of game audio, and determine how to categorise game sound types; and
Identify a means of classifying the visual feedback elements used in a video game user interface;

- **Second iteration:**
  - Data collection and analysis using the feedback categorisation methods identified in the first iteration to:
    - identify the different types of visual feedback used in games; and
    - to determine what visual feedback elements may be used to complement and/or substitute game sound.
  - Development of a game feedback model to represent the relationships between visual feedback elements and audio feedback categories.

- **Third Iteration:**
  - Development of a survey, with questions based on findings of the first and second iterations of this cycle;
  - Conducting the survey to gather qualitative and quantitative data;
  - Analysis of the survey data; and
  - Interpretation of the data collected. This includes triangulation of the data collected from all iterations of this cycle to confirm or disconfirm findings and inform the next cycle.
5.1 First Iteration - Look

The importance of audio in video games has historically been overlooked. Unlike visuals, audio was not a feature of the earliest video games which often lacked sound altogether. Home video game systems released in the 1970’s, including the Channel F: Fairchild, first produced game sound generated through internal circuitry rather than external sources such as a television set. These sounds were not critical to gameplay, were often limited to simple beeps, and used to prevent boredom (Chang et al., 2007). However, as video games have evolved, so has the game sound, with “game sound engineers … contracted to produce sound and music just as they would for a theatrical movie” (Chang et al., 2007, "Current Developments", para. 1).

Audio in video games now plays a more crucial role, providing feedback and informing the player of in-game instruction and events, increasing interactivity, enhancing user emotions and improving realism (Chang et al., 2007). However, it was discovered during the Look stage of this cycle that little had been written about the importance or topologies of game audio. Existing game design practices and accessibility guidelines for the DHH reflected this.

In the literature review, critical analysis of academic studies and industry guidelines determined that visual feedback elements were commonly recommended as an alternative to audio to foster hearing accessibility. However, these existing sources lacked specificity. For example, guidelines were found to provide limited guidance on how to identify or implement suitable alternative forms of visual feedback for specific audio types.

As a result, the second subsidiary research question sought to identify suitable visual forms of feedback as an alternative to categories of audio, which was:
Sub Research Question 1.2: What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?

This Look stage collected and organised literature to identify a means of classifying forms of audio and visual feedback used in video games. The literature that was collected as part of the Look stage was organised per Table 10, and informed the Think stage.

Table 10 Literature for Cycle 2- Look stage in first iteration

<table>
<thead>
<tr>
<th>Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Literature related to game sound categorisation:</strong></td>
<td>Most sourced literature related to game sound categorisation was found to be based on film theory of diegetic and non-diegetic audio.</td>
</tr>
<tr>
<td>Accessibility guidelines</td>
<td>Accessibility guidelines included in the literature to identify how different forms of sound were classified.</td>
</tr>
<tr>
<td>- Game Accessibility Guidelines (n.d)</td>
<td>Includes a framework for classifying game sound in a First-Person shooter genre game. The framework is based on diegetic theory.</td>
</tr>
<tr>
<td>- Includification (Bartlet &amp; Spohn, 2012)</td>
<td>Provides a means of classifying game sound based on diegetic theory.</td>
</tr>
<tr>
<td>- Making Video Games Accessible (2013)</td>
<td>Provides a framework for classifying game sound based on diegetic theory and semiotic theory.</td>
</tr>
<tr>
<td>- Accessibility in Games: Motivations and Approaches (IGDA, 2004)</td>
<td>Provides a framework to classify game sound based on function in a game. Uses diegetic theory, and categories based on whether the sound is used in the game setting or for an activity.</td>
</tr>
<tr>
<td><strong>FPS Acoustic Ecology Conceptual Framework</strong> (Grimshaw and Schott, 2007)</td>
<td>Few sources of literature were found relating to the classification of visual elements in video games, except for an academic study which influenced various non-academic sources and adaptations.</td>
</tr>
<tr>
<td><strong>Topology of Game Sound</strong> (Stockburger, 2003)</td>
<td>The model is part of a larger study, which discusses methods of increasing player immersion in First-Person Shooter Games. The model is a comprehensive means of classifying visual user-interface elements in a video game. However, the model required adaption to accommodate other video game genres.</td>
</tr>
<tr>
<td><strong>Game Sound Signal-Referent Relationship Framework</strong> (Ekman, 2005)</td>
<td>Various non-academic sources were found which have attempted to adapt the above model to other applications. These are non-academic, however have been included in the sourced literature.</td>
</tr>
<tr>
<td><strong>IEZA Framework</strong> (Huiberts &amp; van Tol, 2008)</td>
<td></td>
</tr>
</tbody>
</table>
5.2 First Iteration – Think

5.2.1 Typologies of Game Sound

Recommendations in current hearing accessibility guidelines, whilst inconsistent, generally include the implementation of visual feedback elements to substitute game audio. Game audio is typically used as an umbrella term, regarding sub-categories such as:

- speech, effects and background music in the Game Accessibility Guidelines ("Game Accessibility Guidelines," n.d.);
- speech, audio cues, and ambient noise in Includification (Bartlet & Spohn, 2012);
- dialogue and sound effects in Microsoft’s video game accessibility guidelines ("Making Video Games Accessible: Business Justifications and Design Considerations," 2013); and
- audio and dialogue in Accessibility in Games: Motivations and Approaches (IGDA, 2004).

These classification types are not dissimilar to those that Huiberts and van Tol (2008) believe are the most common classification of speech, sound and music. This method of classification is “derived from the workflow of game audio production, each of these three types having its own specific production process” (“Typologies for game audio”, para. 1). However, this categorisation of game sound types is inconsistent, fails to distinguish specific forms of game sound, and “says very little about the functionality of audio in games” (Huiberts & van Tol, 2008, "Typologies for game audio", para. 1). Therefore, it was important to establish a solid understanding of game sound types to reference when developing the game assessment framework.

In addition to categorisation of game sound based on production, a common approach to game sound typology is based on the film theory classification of diegetic and non-diegetic audio (Ekman, 2005;
Friberg & Gardenfors, 2004; Grimshaw & Schott, 2007; Huiberts, 2010; Huiberts & van Tol, 2008; Stockburger, 2003). In film, the source of a diegetic sound “is visible on the screen or … implied to be present by the action of the film” (“Diegetic sound”, para. 1). A non-diegetic audio source “is neither visible on the screen nor … implied to be present in the action” ("Diegetic and non-diegetic sounds," n.d., "Non-diegetic sound", para. 1). Diegetic video game audio is similarly defined as sound that originates from, and exists within, the fictional game world. Non-diegetic game sounds exist outside of the fictional game world (Ekman, 2005; Friberg & Gardenfors, 2004; Grimshaw & Schott, 2007; Huiberts, 2010). While diegetic sound classification in video games is a common approach there are varied implementations. As an integral step of the Think stage in this iteration, the sound classifications were critically analysed, and this analysis is presented on the following pages.

Stockburger's Topology of Game Sound

In The game environment from an auditive perspective Stockburger (2003) identified the need for a means of identifying, describing and differentiating the different forms of sounds used in video games. In response, a new typology of sound objects was presented (summarised in Table 11). These sound objects were divided into five categories: speech, effect, zone, score and interface. Each sound object was further classified as belonging to either a diegetic or non-diegetic part of a game environment.

<table>
<thead>
<tr>
<th>Sound Object</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech</td>
<td>Considered a diegetic component, and refers to any spoken language that appears in the game environment. Speech sounds include non-player character speech and narrative voice-overs.</td>
</tr>
</tbody>
</table>
| Effect       | A diegetic component, attached to events or visual objects in the game environment, and “are often used to signal changes in the game state” (“4.2
Effect sound objects”, para. 2). Effect sounds include those generated by in-game objects, player and non-player characters, and events occurring in the game environment.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Diegetic game sounds used to indicate the player-character is in a certain area or environment. This may include birds chirping, trees rustling etc., and are sounds often used to create ambience.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>Non-diegetic sounds, which include any music that appears in the game environment.</td>
</tr>
<tr>
<td>Interface</td>
<td>May be diegetic or non-diegetic, depending on implementation. These are sounds that are linked to a specific interface, such as a menu.</td>
</tr>
</tbody>
</table>

The classification of sound objects, and their origin, is more descriptive than the classification based on game audio production. However, on further analysis, it was determined that certain game sounds do not fit Stockburger’s classification model or overlap between different objects. According to Huiberts and van Tol (2008), this is due to inconsistencies “when describing the categories of sound on one hand (zone, effect and interface) and types of sound on the other (score [or music] and speech)” (“Typologies for game audio”, para. 8).

**FPS Acoustic Ecology Conceptual Framework**

Grimshaw and Schott (2007) acknowledged that “game studies has, at best, been woefully coy about sound in game environment or, at worst, completely ignored it” (p. 474). The authors identified the importance of audio in video games, stating “sound is an omni-directional experience, capable of carrying information about virtual materials and dimensions of the game environment both on-screen and off-screen” (p. 474). In their paper, *Situated Gaming as a Sonic Experience: the acoustic ecology of First-Person Shooters*, the authors proposed a conceptual framework. The framework was used to classify
game sound types and to determine the relationship between the player and game sound in the first-person shooter genre of video games.

Like the concept of sound objects defined by Stockburger (2003), the authors defined game audio as ‘auditory icons’. Auditory icons were classified as being diegetic or non-diegetic. Further, the authors stated that their study required additional classification of diegetic sounds, introducing the terms telediegetic and ideodiegetic, with subcategories of kinediegetic and exodiegetic (Figure 28).

![Figure 28 Visual Representation of Audio Icon Classification adapted from Grimshaw and Schott (2007)](image)

The authors did not provide an extensive description of what constitutes a diegetic or non-diegetic audio icon. A brief explanation was provided for the newly defined terminologies, including (Grimshaw & Schott, 2007, p. 476):

- telediegetic sounds which are sounds produced because of an action performed by other players in the game world. These sounds have an impact on the user in the game world; and
- ideodiegetic sounds which are heard immediately by the user, and include:
o kinediegetic sounds, which are triggered by a player’s actions; and

o exodiegetic sounds, which include any sounds not triggered by a player’s actions.

The study concluded stating the classification system may have use in other genres of video games. However, on review it was determined that the topology lacked specificity. As a result, the classification system was deemed unsuitable for application in this study.

**Game Sound Signal-Referent Relationship Framework**

Ekman (2005) also referred to diegetic film theory in a proposed framework to classify game sound (Figure 29). The framework was developed in response to the author’s belief that audio is “given only minimal attention compared to other forms of content” (p. 1). In addition, the author believed there is a lack of understanding for the function and classification of game sound. The study aimed to highlight the underused potential of sound, and explored how game sound can be better utilised in video games.

<table>
<thead>
<tr>
<th>Diegetic referent</th>
<th>Diegetic signal</th>
<th>Non-diegetic signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diegetic referent</td>
<td>Diegetic sounds</td>
<td>Symbolic sounds</td>
</tr>
<tr>
<td>Non-diegetic referent</td>
<td>Masking sounds</td>
<td>Non-diegetic sounds</td>
</tr>
</tbody>
</table>

**Figure 29 Game Sound Signal-Referent Relationship Framework (Ekman, 2005)**

Expanding on the diegetic and non-diegetic terminologies, the framework incorporates semiotic theory, resulting in four different classifications of game sound (Table 12).
Diegetic sounds | Originate within the fictional game world, and refer to an in-game referent. An example may include closing a door, which instantiates a ‘creaking’ sound, and can be heard by non-player characters in the game.

Symbolic sounds | Exist in the game, referring to an in-game referent, but do not originate from within the fictional game-world. An example may include background music, which is triggered when the player character enters a specific area in the virtual-world.

Masking sounds | Originate within the fictional game world, referring to a referent outside of the game world. An example may include a trigger sound, such as a groaning monster, to alert the player they have entered an area that they are not permitted.

Non-diegetic sounds | Originate outside of the fictional game world, and refer to a referent in the real world. An example may include a ‘blip’ sound to indicate a button click when navigating a menu interface.

IEZA Framework

The IEZA framework is a two-dimensional framework, influenced by Stockburger (2003). The framework was developed to “refine insight in game audio by providing a coherent organization of categories and by exposing the various properties of and relations between these categories” (Huiberts & van Tol, 2008, "The IEZA framework for audio in games", para. 1). Unlike the categorisation defined by Stockburger (2003), the IEZA framework refers only to categories of sound, omitting specific types.
The categories are defined as Interface, Effect, Zone and Affect (IEZA). These are presented in a two-dimensional model (Figure 30), classified as being diegetic or non-diegetic, and belonging to either a setting or activity. The categories are further defined in Table 13.

Table 13 Summary of IEZA Categories adapted from Huiberts and van Tol (2008)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>Interface sounds are non-diegetic, which are any sounds originating from outside of the game world, and are influenced by the player’s activity or a specific event. An example may include the sound of clicking a button in a menu, or when completing an in-game objective.</td>
</tr>
<tr>
<td>Zone</td>
<td>Zone sounds are diegetic, originating from within the fictional game world. These sounds are not directly influenced by the player, and relate to the setting, or environment, providing ambience and background noise, or anticipation for upcoming events. Example sounds may include weather, such as wind, rain, or thunder; or a rooster crowing to indicate the time of day.</td>
</tr>
<tr>
<td>Effect</td>
<td>Effect sounds are diegetic, existing within the game world, and are directly influenced by player activity. These types of sounds may include footsteps when the player is walking, weapon fire or character dialogue.</td>
</tr>
<tr>
<td>Affect</td>
<td>Affect sounds are non-diegetic, are not directly influenced by the player activity, and are used to communicate the setting or mood of the game. These sounds do not originate from the game world, and may include background music, such as music with a fast tempo to indicate urgency, and expressive sound effects, such as a synthetic screeching sound in a horror game.</td>
</tr>
</tbody>
</table>
Each of the reviewed sound classification models were organised in Table 14, with strengths and limitations identified. From the analysis, it can be surmised that the generally accepted approach to classify game sound is via diegetic theory, although there are varied implementations. Further, while distinct similarities can be drawn, the IEZA model and Game Sound Signal-Referent Relationship Framework were identified as the most comprehensive. However, a decision of suitable framework was not finalised until the review on visual feedback types was conducted. It was proposed that once a means of identifying visual feedback had been determined, a compatible sound classification model would be decided.

Table 14 Analysis of sound classification models

<table>
<thead>
<tr>
<th>Model</th>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessible design guidelines</td>
<td>• Commonly used in industry, based on production process.</td>
<td>• Has inconsistencies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Doesn't identify all forms of game sound, or describe functionality of sound types.</td>
</tr>
<tr>
<td>Stockburger’s Topology of Game Sound</td>
<td>• Based on existing theory used in film.</td>
<td>• Not all game sounds can be appropriately classified.</td>
</tr>
<tr>
<td></td>
<td>• Identifies some sounds and provides descriptive categories.</td>
<td>• Some inconsistency with categories and types of sound.</td>
</tr>
<tr>
<td>FPS Acoustic Ecology Conceptual Framework</td>
<td>• Based on existing theory for categorisation of sound in FPS games</td>
<td>• Lacks specificity for categories</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Difficult to generalise to other genres</td>
</tr>
<tr>
<td>Game Sound Signal-Referent Relationship Framework</td>
<td>• Uses existing theories for basis (semiotics and diegetic film theory).</td>
<td>• Terminology not commonly used in industry</td>
</tr>
<tr>
<td></td>
<td>• More comprehensive than most other reviewed models</td>
<td>• May cause confusion with terminology, which does not conform to the standard classification based on the production process.</td>
</tr>
<tr>
<td>IEZA Framework</td>
<td>• Builds on previous sound classification models.</td>
<td>• Terminology not commonly used in industry</td>
</tr>
<tr>
<td></td>
<td>• Identifies and addresses limitations in similar models.</td>
<td>• May cause confusion with terminology, which does not conform to the standard classification based on the production process.</td>
</tr>
<tr>
<td></td>
<td>• Comprehensive and permits the identification of all forms of sound.</td>
<td></td>
</tr>
</tbody>
</table>
Following on from this critical analysis of sound classification frameworks, it was also necessary to critically analyse visual feedback classifications. This analysis is presented below.

5.2.2 Visual Feedback Classification

To determine what visual feedback elements may be used to substitute game audio, an investigation was conducted to identify and classify the different visual elements of a video game user interface. It was anticipated that, by combining the results from the game sound topology analysis with a method of classifying visual elements, a model may be developed to determine what visual elements may be used to substitute specific categories of game sound. However, on investigation, it became apparent that there were few academic publications focused on the classification of visual elements for video games.

Existing publications tended to focus primarily on the technical aspects of visual design, including:

- Programming, scripting and middleware (Ayangbekun & Akinde, 2014; Fox, 2005; Suma et al., 2013);
- user created modifications for interfaces in video games (Targett, 2011); and
- user experience (UX) design, and the impact of user interface design on immersion (Fagerholt & Lorentzon, 2009; Johnson & Wiles, 2003; Quintans, 2013).

These publications were found to lack any means of classifying the visual elements of a video game. Further, publications for other mediums, such as web and computer software, were found to be unsuitable given the uniqueness of the video game medium (Poh, n.d.).
One exception was *Beyond the HUD: User Interfaces for Increased Player Immersion in FPS Games* (Fagerholt & Lorentzon, 2009). The study involved an investigation into how immersion is related to the user interface in the first-person shooter (FPS) genre of video games. The terminology user interface (UI) is used to refer “to all informative elements within a game, regardless of whether it is channeled [sic] visually, auditory or by haptics” (p. 3). While the focus of the study was targeted towards immersion and user experience design, the research included a comprehensive analysis on the different visual elements of a UI, including a new method of classification.

![Figure 31 Representation of the UI layers in an FPS (Fagerholt & Lorentzon, 2009)](image_url)

As part of the classification, the visual UI of an FPS was segmented into layers (Figure 31), consisting of:

- a **world layer**, which includes anything that is visually represented within the spatial game world, from a first-person perspective;
- a **filter layer**, which is like filters in cinematography where a visual effect such as a blur, grain or colour is imposed over the game world layer;
- an **avatar**, which is a representation of the player’s character and positioned through the filter layer; and
- an **overlay layer**, which refers to any other visual component that is superimposed over the world, avatar and filter layers.
Further, the authors identified a distinction between the fictional game world and the 3D game space. The underlying theory was influenced by diegetic film theory, and includes:

- the fictional game world, which “describes the more subjective and optional parts of the game such as the world setting and story of the game” (p. 12); and
- the 3D game space, which is the spatial world layer in a first-person shooter genre game.

These concepts were combined and presented in a model to classify specific video game user interface (VGUI) elements (Figure 32).

![Figure 32 Model of design space of user interfaces in FPS Games (Fagerholt & Lorentzon, 2009)](image)

Using the model, visual elements can be defined by whether they exist within the spatial environment and in the fictional game world. Individual elements can then be identified as belonging to a specific predefined category. These categories include head-up display (HUD), geometric, diegetic, and meta elements and signifiers, all of which are accompanied by detailed textual descriptions.
The model provides a comprehensive means of categorising individual visual VGUI elements in a FPS game. However, analysis determined that there was some inconsistency with the core categories. For example, the HUD element is depicted in the model and referred to in-text only as non-diegetic. Yet, an analysis on HUDs determined they are a type of UI element, not a category, and may be either diegetic or non-diegetic depending on implementation. The specificity of the model’s element categorisation did present potential issues with flexibility and generalisation for use with other game genres for this research. However, it was discovered that an adaptation of the core model had previously been developed.

![VGUI Classification Model](image)

**Figure 33 VGUI Classification Model (Stonehouse, 2014)**

The revised VGUI classification model (Figure 33) was based on an adaptation of Fagerholt and Lorentzon’s (2009) model and introduced by Stonehouse (2010) in his blog. It has since been frequently cited as a fundamental principle in VGUI design, and several versions of the adapted model were found to exist (Andrews, 2010; Leon, 2015; Russell, 2011; Stonehouse, 2014). The model differs from the original, permitting the identification and classification of visual VGUI elements in all video
game genres (Stonehouse, 2014). Elements are categorised into one of four core categories: non-diegetic, meta, diegetic, and spatial.

While the amended model addressed some of the issues identified with the original model, the source was identified as non-academic and lacked some specificity. This included a lack of reference to the representation of the UI layers in an FPS and consistency in terminology, which was considered critical in identifying where visual elements appeared in a video game’s user interface.

5.2.3 Adapted Video Game User Interface Classification Model

From the critical analysis of the visual feedback categorisation it was necessary to devise a more inclusive VGUI classification model. This first required the development of a new video game user interface (VGUI) representation to assist in defining revised terms and concepts for all genres of video games (Figure 34). This replaced the original representation (Figure 31), which was specific to the FPS genre of video games.

![Figure 34 New Video Game User Interface Representation](image)

The new representation describes the relationship between the player and their perspective of the VGUI. Like the original representation (Figure 32), the new VGUI comprises the:
• The **Spatial Game Space** layer, which is representative of the physical game world, and any visual feedback element that is visually represented within the spatial game space;

• The **Filter** layer, which is imposed over the spatial game space and used for the application of visual feedback elements outside of the physical game world. These elements do not provide detailed information, and instead consist of visual effects like filters in cinematography; and

• The **Overlay** layer, which includes any other visual feedback element that is superimposed over the Spatial Game Space and Filter layers.

It is important to note not all layers are mandatory as an analysis on several video games determined that visual feedback elements may exist solely within the spatial game space. Further, the avatar layer was excluded due to the visual representation of the player character being dependent on the game genre. For example, in a side-scrolling platform or top down perspective game the player’s avatar may exist solely in the spatial game space. Alternatively, a puzzle or card game may not include an avatar at all.

Figure 35 Visual Feedback Classification Model (Based on Deshmukh, 2010; Fagerholt & Lorentzon, 2009; Russell, 2011; Stonehouse, 2014)
Once the new VGUI representation was developed, the terms were used to develop a new video game Visual Feedback Classification model (Figure 35). The structure of the model is based on the original model defined by Fagerholt and Lorentzon (2009) (Figure 31), with new terminologies as defined in the new VGUI representation (Figure 32). Further, the model excludes the specific element categories defined by Fagerholt and Lorentzon (2009) and the choice was informed by the generalised adapted industry models.

5.3 First Iteration - Act

The **Think** stage of the first iteration in Cycle 2 investigated methods of classifying the audio and visual feedback elements in video games. Investigation identified one academic study (Fagerholt and Lorentzon, 2009) which provided a classification model for visual elements in the first-person genre of video games. Several non-academic adaptations of the classification model were found to exist (Andrews, 2010; Leon, 2015; Russell, 2011; Stonehouse, 2014), and were frequently cited as a fundamental principle in video game design. The adapted versions lacked reference to the core concepts of the original model, such as the layers of a video game user interface (see 5.5.2), and a new visual feedback classification model (Figure 35) was developed to address the limitations.

Once this new visual feedback classification model was created, a suitable video game sound classification model was selected. From the analysis in the **Think** stage in this iteration, two potential game sound classification models were shortlisted:

- the IEZA Framework (Huiberts and van Tol, 2008); and
- the Game Sound Signal-Referent Relationship Framework (Ekman, 2005)
These two models were shortlisted due to their comprehensiveness in classifying game sound types after exploring the strengths and limitations of all models (Table 14).

For final selection, the structure of the IEZA model (Figure 30) was deemed to be the most compatible with the new visual feedback classification model (Figure 35). This was due to the IEZA model being based purely upon diegetic film theory, and providing a comprehensive means of identifying whether sound belonged to an interface, effect, zone, or affect category. While the Game Sound Signal-Referent Relationship Framework (Figure 29) was also based on diegetic film theory it included classification using semiotic theory. This added a layer of complexity, with surplus, that did not provide additional information which had not already been covered by the IEZA model (Figure 30). The results of this cycle led to the identification of the following feedback classification models for use in this research:

- the new visual feedback classification model (Figure 35) for the identification of visual feedback elements; and
- the IEZA framework (Figure 30) (Huiberts and van Tol, 2008) for the identification and classification of audio feedback elements. All instances of the categorical terms Interface, Effect, Zone, and Affect, used in the body of the text in this thesis, are presented in italics to assist in differentiating a sound category terminology from regular usage.

Upon completion of this iteration, it was determined that a second iteration was required to use both feedback classification models to identify specific visual feedback elements and the interrelationships with audio feedback categories. It was intended to use this information in future cycles to determine what visual elements can be used to substitute or complement audio feedback, and facilitate accessible game design for the DHH.
A core characteristic of the Look, Think, and Act action research process (Stringer, 2013) includes using the results of findings in the Think stage to develop a plan for action in subsequent cycles or iterations. As identified in Think stage of this cycle, and in the literature review, it was frequently recommended to use visual feedback elements to complement or substitute specific forms of audio feedback in games (Bartlet & Spohn, 2012; Fagerholt and Lorentzon, 2009; "Game Accessibility Guidelines," n.d.). However, these recommendations lacked specificity and failed to identify specific forms of visual feedback types or the corresponding audio feedback types.

The planning in this Act stage introduced the data collection and analysis concept of anecdotal observations of video games, using the two classification models. This resulted in the development of a new table of feedback types (Table 15). The table was developed based upon the two feedback classification models:

- The new visual feedback classification model categories which informed the table rows; and
- The IEZA framework categories which informed the table columns.

Table 15 New Table of Feedback Types

<table>
<thead>
<tr>
<th>Visual element (Identified via the new visual feedback classification model)</th>
<th>Game Audio Feedback Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Non-Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Effect (Activity)</td>
</tr>
<tr>
<td></td>
<td>Zone (Setting)</td>
</tr>
<tr>
<td></td>
<td>Interface (Activity)</td>
</tr>
<tr>
<td></td>
<td>Affect (Setting)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-Diegetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diegetic</td>
</tr>
<tr>
<td>Spatial</td>
</tr>
<tr>
<td>Meta</td>
</tr>
</tbody>
</table>
The table was used for data collection in the *Think* stage of Cycle 2, iteration 2, to document the visual elements identified during anecdotal observations of video games, and to record which audio feedback categories the visual elements were used for. The method of data collection is as follows:

1. During observations of video games, visual feedback elements which are used to complement or substitute audio are identified in a game.

2. The new VGUI representation model (Figure 34) is used to determine the visual element’s layer, and the visual feedback classification model (Figure 35) is used to determine whether the element is in the fictional or spatial space.

3. The element is compared with the visual feedback elements previously identified in literature (Table 16) to see if the element has been previously defined. If the element has not been defined, a new descriptive terminology is created.

4. This element is placed into the new Table of Feedback Types (Table 15), with corresponding *interface, effect, zone* and/or *affect* audio categories recorded in the relevant columns.

5. Further observations of the element, used to substitute or complement categories of game sound, are recorded in the corresponding columns in the Table of Feedback Types (Table 15).

### Table 16 Visual elements identified from literature

<table>
<thead>
<tr>
<th>Visual elements</th>
<th>Description</th>
<th>Source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUD Elements</td>
<td>An element that appears in the overlay layer of the VGUI to provide descriptive information.</td>
<td>(Fagerholt &amp; Lorentzon, 2009)</td>
</tr>
<tr>
<td>Geometric Elements</td>
<td>Are visual representations in the spatial game world, but not the fictional game world.</td>
<td>(Fagerholt &amp; Lorentzon, 2009)</td>
</tr>
<tr>
<td>Diegetic elements</td>
<td>Informative visual elements in the spatial and fictional space.</td>
<td>(Fagerholt &amp; Lorentzon, 2009)</td>
</tr>
<tr>
<td>Meta-representations</td>
<td>A visual element that is part of the fictional game world but outside of the spatial world.</td>
<td>(Fagerholt &amp; Lorentzon, 2009)</td>
</tr>
<tr>
<td>Meta-perception</td>
<td>Visual elements that are not part of the spatial game world, may or may not be connected to the game fiction. This requires additional exploration.</td>
<td>(Fagerholt &amp; Lorentzon, 2009)</td>
</tr>
<tr>
<td>Signifiers</td>
<td>Elements part of both the fictional and spatial game world, to provide information is a subtle manner.</td>
<td>(Fagerholt &amp; Lorentzon, 2009)</td>
</tr>
<tr>
<td>Alternative reactionary input/subliminal cues</td>
<td>A visual cue used to indicate something important is happening in the game world. This is subtle and may include changes of screen overlay colour, controller vibrations etc.</td>
<td>(Bartlet &amp; Spohn, 2012)</td>
</tr>
<tr>
<td>Closed captioning</td>
<td>Text based feedback. Recommendations include using changeable font size, colours and font. Allow text to be displayed before sound is played, with the option for representing ambient noise as well as speech. Text-per minute speed should be suitable for target age group.</td>
<td>(Bartlet &amp; Spohn, 2012; &quot;Game Accessibility Guidelines,&quot; n.d.)</td>
</tr>
<tr>
<td>Sign language</td>
<td>Not seen in games, but possible to be used. Need to consider localisation.</td>
<td>(&quot;Game Accessibility Guidelines,&quot; n.d.)</td>
</tr>
</tbody>
</table>

An example implementation is as follows:

1. A new visual element is identified in a game, and found to complement the *interface* category of game sound.

2. The element is found to exist in the overlay layer of the VGUI representation model, and does not exist in the spatial or fictional space of the visual feedback classification model. These findings define the visual element as non-diegetic.

3. The element is found to have been previously defined in literature as a HUD element with an existing terminology and description.

4. The HUD element is placed into the new Table of Feedback Types (Table 17), and the corresponding *interface* category of sound is recorded in the adjacent column.

5. Further observations find that the non-diegetic HUD is also used for *effect* and *zone* sounds, and the table is updated with the new information (Table 17).
Table 17 New Table of Feedback Types example entry for data collection

<table>
<thead>
<tr>
<th>UI Element</th>
<th>Game Audio Feedback Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Effect (Activity)</td>
</tr>
<tr>
<td>Non-Diegetic</td>
<td>✔</td>
</tr>
<tr>
<td>HUD</td>
<td>✔</td>
</tr>
<tr>
<td>Diegetic</td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td></td>
</tr>
<tr>
<td>Meta</td>
<td></td>
</tr>
</tbody>
</table>

This led to the conclusion of the first iteration for Cycle 2.

5.4 Second Iteration - Look

In the second iteration of Cycle 2, the new Table of Feedback Types developed during the Act stage of Cycle 2, iteration 1, was used for data collection and analysis in the following Think stage. The table was used to identify and categorise the visual feedback elements used in video games, and the corresponding categories of audio feedback. Visual elements were identified from observations conducted on forms of video games (Table 18), and literature sourced from:

- the original visual feedback categories used in a first-person shooter defined by Fagerholt & Lorentzon (2009)
- in accessibility guidelines (Bartlet & Spohn, 2012; "Game Accessibility Guidelines," n.d.)
<table>
<thead>
<tr>
<th>Visual element</th>
<th>Description</th>
<th>Audio Feedback Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-up display</td>
<td>Found in both the diegetic and non-diegetic sectors of the VGUI model. Used to provide descriptive information. Also identified dynamic HUDS- which adapt or change in response to in-game events or player action.</td>
<td>Effect, zone and interface</td>
</tr>
<tr>
<td>Directional markers</td>
<td>Found in the non-diegetic sector. Used to provide information regarding locations or objectives in the overlay layer.</td>
<td>Effect and interface</td>
</tr>
<tr>
<td>Captions and subtitles</td>
<td>Textual information found in games as part of the non-diegetic VGUI sector. Appears in the overlay layer. The implementation between games differs greatly.</td>
<td>All categories</td>
</tr>
<tr>
<td>Geometric/contextual icons</td>
<td>Icons or images that appear in the spatial game world, but not always part of the game fiction. The elements generally appear in the overlay layer, but may also appear in the spatial layer.</td>
<td>Effect and interface</td>
</tr>
<tr>
<td>Silhouettes, highlights and outlines</td>
<td>A diegetic element used to highlight objects and people in the spatial game layer. Not typically part of the game fiction.</td>
<td>Activity and setting</td>
</tr>
<tr>
<td>Breadcrumb trails</td>
<td>A glowing trail that appears in the spatial game world. Examples found are part of the game fiction, making it a diegetic element.</td>
<td>Effect</td>
</tr>
<tr>
<td>Signifiers and subliminal cues</td>
<td>These visual elements appear in the spatial game world, and are part of the game fiction. They are subtle cues, and may include smoke to indicate fire, blood splatter to indicate danger etc.</td>
<td>All categories</td>
</tr>
<tr>
<td>Lighting</td>
<td>Lighting was found to be used to provide information as part of the game fiction and spatial world, making it a diegetic element.</td>
<td>All categories</td>
</tr>
<tr>
<td>Particle systems</td>
<td>Particle systems are used in a variety of games, and are part of the game fiction and spatial world, making it a diegetic element.</td>
<td>Effect, Zone and Interface</td>
</tr>
<tr>
<td>Avatar signing and expressive body language</td>
<td>A single example of signing was found in a trailer for an upcoming game. The usage is in both the spatial game world and part of the game’s fictional space. In addition, the use of facial expressions and body language used by in-game characters was found to a visual feedback element that exists in both the game world and fictional space.</td>
<td>All categories</td>
</tr>
<tr>
<td>In-game devices</td>
<td>A device used in game to provide information. It exists in the game fiction, but may appear in the spatial game space or take the player outside of the game world. As a result, it may be a diegetic or meta element.</td>
<td>All categories</td>
</tr>
<tr>
<td>Screen filters</td>
<td>A camera filter that appears in the filter layer as a meta element. Includes things like water droplets on the screen, greying of the world to indicate near death etc.</td>
<td>Effect and Zone</td>
</tr>
</tbody>
</table>
This data informed the *Think* stage of this cycle where analysis and refinement of the individual elements was conducted, with accompanying thick textual descriptions. Findings were used to inform a populated table of feedback elements, survey design in the third iteration, and in the final interpretation of data for this cycle.

### 5.5 Second Iteration - Think

To analyse the usage of visual feedback elements used in video games, and correlate these with audio feedback types, an assessment of video games was conducted. This assessment used video games of varying commercial success (see Table 7 for a complete list of games), based on:

- best practice examples from video game accessibility guidelines (Bartlet & Spohn, 2012; "Game Accessibility Guidelines," n.d.);
- recommendations from community-based websites and social network community groups; and
- based upon the researchers own knowledge.

This section describes this video game analysis, with reference to the four categories in the Visual Feedback Classification Model as in Figure 35.

#### 5.5.1 Non-diegetic elements

The non-diegetic section of the Visual Feedback Classification model refers to any feedback element that does not exist in the spatial game space or the fictional game world (Figure 36). Non-diegetic elements typically appear in the overlay layer of the Visual Feedback Classification Model (Fagerholt
& Lorentzon, 2009). Results from critical analysis of literature and observations of several games determined common non-diegetic elements include:

- head-up display;
- subtitles and closed captions;
- directional markers; and
- avatar overlays.

![Diagram](image)

Figure 36 Non-diegetic element in the Visual Feedback Classification Model

### 5.5.1.1 Head-up Display

The Head-Up Display (HUD) element “is frequently used to simultaneously display several pieces of information such as the main character’s health, items, and indicators of game progression and goals” (Fagerholt & Lorentzon, 2009, p. 1). This visual element was identified by Fagerholt and Lorentzon (2009) as being a purely non-diegetic element. However, review of several video games has determined that a HUD may be either diegetic or non-diegetic. Diegetic HUDs are discussed further in the discussion on diegetic elements. Non-diegetic HUDs are used in a wide variety of game genres, and are suitable for conveying information which requires a high level of detail (Fagerholt & Lorentzon, 2009).
An early example includes Nintendo’s (1987) side-scrolling platform game *Super Mario Bros.* (Figure 38). The game’s HUD appears at the top of the screen, in the overlay layer. The information provided includes the player’s score, number of coins collected, current level, and timer to indicate the remaining time to complete the level.

This game includes forms of audio feedback from all audio categories in the IEZA framework. However, audio feedback from the *affect* category is used to provide feedback critical to gameplay. The player is required to complete each level within a specific time frame, which is evident through the game’s music. As time runs out, the music pace increases urging the player to move more quickly and
complete the level. This is accompanied by a timer in the HUD, which provides explicit visual feedback, complementing the affect sound category.

A recent example is Irrational Games’ (2013) first-person shooter BioShock Infinite (Figure 39). The HUD primarily consists of the player’s health and shield meter which depletes when the character is injured. The character’s current selected special ability is also shown in the bottom left, accompanied by a meter to measure a consumable resource. Finally, the currently selected weapon is shown, in the bottom-right, accompanied by an ammunition count. This health bar in the HUD is used in conjunction with an effect sound which is triggered when the player is damaged. This is visually depicted by depleting the health bar by the amount of damage incurred relative to the player’s total health.

Figure 39 BioShock Infinite HUD (Irrational Games, 2013)

In addition to the traditional structure of a HUD, HUD elements may also be dynamic. These types of HUD elements alter in appearance in response to player activity, events, or the game environment. BioShock Infinite’s HUD comprises of several dynamic elements which become visible and provide feedback in response to a specific events or encounters. These include notifications of new objectives through pop-ups, which are accompanied by an interface sound (Figure 40).
Fallout 4 (Bethesda Game Studios, 2015), a first-person action role-playing game, also includes a HUD. The HUD comprises a health bar, ammunition count, and a compass indicating the direction of objectives (Figure 41). The HUD also includes dynamic elements in addition to audio feedback. For example, entering an environment with high levels of radiation will have a negative effect on the player, reducing the player’s health. Environmental areas with high levels of radiation are indicated audibly using an effect sound of a Geiger counter clicking. The sound becomes more prominent the higher the levels of radiation. This feedback is also represented visually, with a dynamic HUD element appearing showing the amount of radiation exposure incurred. In addition, the HUD alters in appearance when the player equips a mechanical suit of power armour (Figure 42). The altered HUD includes information specific to the armour, such as location specific damage indicators and battery power.
5.5.1.2 Directional Markers

Similar elements to dynamic HUD components are directional marker elements. Directional markers were a new visual element identified as a means of notifying the player of an encounter or event such as a waypoint for the location of an objective. For example, first and third person shooter games *Gears of War III* (Epic Games, 2011), *Star Wars: Battlefront* (*"Star Wars: Battlefront,"* 2015) and *Fallout 4*
implement directional markers to assist the player in locating the source of an enemy who is attacking them. While the enemy location may be identified audibly as an effect sound element, such as a gunshot, the directional markers provide the feedback visually appearing around the player’s reticle as red arrows or ellipses (Figure 43).

![Figure 43 Gears of War III directional marker (Epic Games, 2011)](image)

5.5.1.3 Captions and Subtitles

Captions and subtitles are a textual description of game sound (Figure 44), which appear in the overlay layer of the VGUI representation (Figure 34). On review of accessibility guidelines and through observations of video games, it became apparent that there were numerous methods of implementation. Further investigation of literature determined that, unlike the internationally recognised Web Content Accessibility Guidelines ("Web Content Accessibility Guidelines (WCAG) 2.0" 2008), there is no internationally accepted standard or definition for captions or subtitles in video games (Media Access Australia, n.d.).
For example, in the United Kingdom, subtitles and captions are terms used interchangeably and refer to “timed-text displayed on video that includes both speech and essential non-speech sounds” (Griffin, 2008, "Note", para. 1). In Australia, the United States, and Canada, subtitles and closed captions are defined independently. Subtitles are considered straight transcriptions or translations of dialogue “used as a way of translating a medium into another language so that speakers of other languages can enjoy it” (“Different Contexts for Subtitles and Captions”, para. 1). Captions include the same textual description of speech, but also include descriptions of sounds and music, and are used specifically to aid DHH audiences (Accredited Language Services, 2010, "Different Contexts for Subtitles and Captions", para. 2).

In addition, depending on locale, there are varied standards or guidelines for both subtitles and captions for film and television. Guidelines relate to reading speed, position, colour, font size, punctuation, line length and breaks, and speaker identification. However, guideline specifications tend
to differ greatly, and suppliers of commercial captions have their own guidelines which are not made readily available to the public (Media Access Australia, n.d., para. 3). As a result, few video games provide consistent or suitable options for both captions and subtitles, with design choices dependent on the developer. This has resulted in varied methods of implementation, and the video game community voicing disapproval. *Rise of the Tomb Raider* (Crystal Dynamics, 2013) is one such game, which received criticism from the video game community after implementing subtitles with both dialogue and essential non-speech sounds. Subtitles could be turned on or off, but lacked an option to elect subtitles solely for speech. This resulted in mixed reactions on public web-based discussion forums, with comments such as “the implementation of subtitles was terrible in this game” (*Ninja_, 2013).

In contrast, some participants acknowledged the importance of descriptive captions. This included one participant stating that having descriptive text for “sounds, both on-screen and off, is just as important for the hearing impaired as it is to have the dialogue itself displayed” (Spong, 2013). Other participants provided suggestions for improvement, such as the option to have “dialog only, and full subtitles for hearing impaired (including sound effects)” (Cochrane, 2013).

Similar posts for other video games litter the web, culminating in a recent web forum thread titled "Dear developers: Learn how to do subtitles, because you obviously have no clue!" (2015). The thread generated significant discussion, and directly influenced the development of a guide for developers titled *How to do subtitles well – basic and good practices* (Hamilton, 2015). The guide identified current issues with the textual forms of feedback, and discussed how poorly implemented subtitles can have an adverse impact on a gamer’s experience.
Hamilton’s (2015) guidelines addressed common issues, including the identification of subtitles and captions, and were developed based on standard practices from other industries. In addition, his guidelines were developed in collaboration with industry professionals and video game accessibility experts, resulting in a comprehensive and informative guide for the development and implementation of textual feedback in video games. This included three fundamental principles (Hamilton, 2015, "Basics"): 

- The contrast between the text colour and background;
- The size of the text displayed on the screen; and
- The amount of text displayed on screen at one time.

Ten good practices were also identified (Hamilton, 2015, "Good practices"): 

1. Ensuring the textual feedback is accurate to what is happening in the game or is being spoken;
2. Allow textual feedback to be enabled before any crucial audio information is used;
3. Position the subtitles or captions where they will not clash with other VGUI elements;
4. Add subtitles from the bottom if new lines of text are added to existing text;
5. Include a means of identifying who is speaking;
6. In addition to the above practice, if the source of the sound is not on the screen, use a directional indicator to show where the sound is coming from;
7. Allow an appropriate amount of time for on-screen text to be read;
8. Ensure font is clear and easy to read, without clashing with the art direction of the game;
9. Permit the customisation of the font by allowing font type, size, transparency etc. to be modified.
10. Include the option to implement either subtitles, for dialogue, and full captions, for all sounds.
Hamilton (2015) believed that the improvements to subtitles and closed captions benefits not only DHH gamers but a clear majority of the gaming population. This is supported by a quoted statistic, where 79 percent of all gamers were found to play games with subtitles enabled (Rivera & Kaminski, 2011, cited in Hamilton, 2015). However, the source is unscientific with no data related to sampling size or method. As a point of interest for this research, it was determined that this required further investigation given findings in the literature review. This included the opinions by some developers that accessibility considerations benefit only a minority of the gaming demographic and not worth the potential return on investment.

Based on these findings, this research identified subtitle and closed caption visual feedback elements independently. This permitted the forms to be analysed individually with:

- subtitles being identified for complementing or substituting sound; and
- closed-captions complementing all categories of game sound.

5.5.1.4 Virtual Signing Avatar Overlay

The use of a signing avatar overlay in video games is a new concept. This section exists solely to acknowledge the potential for future research and applications in the area. Signing was identified as a potential form of feedback in accessibility guidelines ("Game Accessibility Guidelines," n.d.). However, no examples were provided for the technical ways in which to implement the feedback element. As a result, this section was based on similar applications in other forms of media. This included the use of human interpreter overlays for television (Figure 45), and research conducted into the use of procedurally animated virtual characters (Clymer, Geigel, Behm, & Masters, 2012; Romeo, Pachecho, & Blat, 2014)
A virtual signing avatar overlay is a 2D or 3D animated virtual character, presented in the overlay layer of the VGUI. The avatar is used to interpret both dialogue and other game sounds and music, and communicates those interpretations through facial expression and hand signs. This form of animation may be pre-rendered or procedurally animated.

Pre-rendered animations are those which are animated and recorded for later use. Procedural animation methods refer to the use of virtual characters to interpret audio or text on the fly. This process involves translation from a data source, such as a text transcript or live interpreter motion capture, which is then rendered as animated sign language (Figure 46) ("Avatars make the Internet sign to deaf people," 2014; Romeo et al., 2014).

It is proposed, by this researcher, that while procedurally animated signing avatar overlay support may be included in game software, it may also be embedded at system level. For example, gaming consoles may include an embedded option to interpret spoken audio in video games. The spoken audio would be translated to gestures performed by an avatar in the overlay layer (Figure 46).
5.5.2 Spatial Elements

Spatial elements are visual forms of feedback which exist in the spatial game layer of the VGUI representation (Figure 47). These elements are not part of the fictional game world, and cannot be seen or heard by the game characters. According to Fagerholt and Lorentzon (2009), spatial components have similar advantages to non-diegetic elements, including the potential provide highly detailed information. The spatial elements identified in this research included:

- geometric contextual icons and text;
- silhouettes, outlines and focus highlights; and
- breadcrumbs.
5.5.2.1 Geometric Contextual Icons and Text

Geometric contextual icons and text are visual elements used to notify the player about the significance of an object or event in the game environment. These elements are not part of the fictional game world, and exist solely in the spatial game space. For example, in *The Order: 1886* (Ready at Dawn, 2015) objects which can be interacted with are identifiable by a geometric icon in the form of a small grey circle (Figure 48).
Kojima Productions’ (2015) stealth-action game *Metal Gear Solid V: The Phantom Pain* uses similar geometric icons in addition to sound. Enemy non-player characters patrol the environment, and the player is often required to navigate the area undetected. If the player is detected, a one-shot *interface* sound alerts the player, and an exclamation mark appears above the non-player character’s head (Figure 49).

![Figure 49 Metal Gear Solid V: The Phantom Pain- geometric icon (Kojima Productions, 2015)](image)

Similarly, in Blizzard Entertainment’s (2012) isometric role-playing game, *Diablo III*, non-player characters (NPCs) will appear with an exclamation mark above their heads. The geometric icon indicates the NPC has information for the player (Figure 50). On occasion, this geometric element may also be accompanied by an *effect* sound, where the non-player character verbally acknowledges the player.

During the observations of video games, *Diablo III* was found to utilise visual geometric elements extensively. For instance, when a monster is killed or a container is opened, weapons, equipment and other items will drop to the ground for the player to collect. Each item has a different level of quality, related to its rarity and value, indicated by a specific colour. The game settings also provide an option
for players to display a colour coded geometric textual description above each dropped item (Figure 51). Furthermore, when an item of the highest quality level drops, a one-shot effect sound is used to alert the player. This sound is accompanied by a coloured beam of light as an additional form of feedback for the effect sound category (Figure 51).

Figure 50 Diablo III Geometric Indicator for a Quest Giver (Blizzard Entertainment, 2012)

Figure 51 Diablo III Visual Feedback for Item Drops (Blizzard Entertainment, 2012)
Naughty Dogs’ (2013) *The Last of Us* is a third-person, post-apocalyptic survival game, where the player navigates through a variety of environments to reach objectives. Each environment includes a variety of friendly and hostile non-player characters. To aid the player in identifying friendly characters, white diamond icons are displayed above their heads. In addition, geometric contextual icons are used to identify the source of individual effect sounds a character makes via a circular sonar icon:

- footstep effect sounds are indicated by a sonar icon located below a character’s feet (Figure 52);

and

- verbal effect sounds are indicated by a sonar icon located around a character’s head (Figure 53).

![The Last of Us: Geometric Outlines and Icons](image)

**Figure 52 The Last of Us: Geometric Outlines and Icons (Naughty Dog, 2013)**

### 5.5.2.2 Silhouettes, Outlines and Focus Highlights

As a means of attracting the player’s attention towards a specific game object or event, silhouettes, highlights and outlines were identified. These visual feedback elements are used as a means of distinguishing an object or event from the surrounding environment in the spatial world layer. While the player can see the geometric indicator, the characters in the game cannot.
In *The Last of Us* (Naughty Dog, 2013), non-player characters include both friendly humans and hostile infected and mutated creatures. As discussed in *Geometric Contextual Icons and Text*, the player is alerted to the NPC’s presence by unique *effect* sounds such as humans talking or infected creatures clicking and screaming. These sounds allow the player to better navigate their surroundings, employing different strategies to either avoid or confront hostile non-player characters.

In addition to the *effect* sound feedback, the game features a listening mode which can be activated through a button press on the game controller at any time. Listen mode allows the player’s character “to use their heightened sense of hearing and spatial awareness to more effectively locate enemies … by showing the player silhouettes of characters through walls and barriers” (“Listen Mode,” n.d., "Singleplayer", para. 1). Both friendly and hostile characters are outlined in white, and silhouettes appear only when a character is producing noise. The outline gradually fades when a non-player character is silent (Figure 53).

![Figure 53 The Last of Us: Geometric Outlines for Game Objects (Naughty Dog, 2013)](image)
Similarly, in *Rise of the Tomb Raider* (Crystal Dynamics, 2013), a button press on the game controller will activate ‘survival instinct’ vision. When activated, the screen turns greyscale and objects of interest are highlighted in gold. The game’s objectives include solving complex puzzles in the spatial game world, by moving objects, pulling levers and other tasks. As the player attempts to solve the puzzles, the player’s character will provide *effect* sound feedback through verbal hints. These verbal prompts are shown via subtitles in the overlay layer if enabled. However, activating survival mode will highlight the hinted objects in gold, complementing the *effect* audio feedback, to aid the player in solving the puzzle.

![Rise of the Tomb Raider survival instinct mode](image)

Figure 54 Rise of the Tomb Raider survival instinct mode (Crystal Dynamics, 2013)

### 5.5.2.3 Breadcrumbs

An additional form of visual geometric feedback includes breadcrumbs, or glowing trails. The terminology ‘breadcrumbs’ was defined for this research to refer to a visual feedback element not previously identified in guidelines or academic literature. Breadcrumbs provide a directional visual indication, aiding a player in finding a specific location, game object, task, or event ("Glowing Trail," n.d.). For example, Lionhead Studios’ (2010) *Fable III* uses breadcrumbs to direct the player to their next objective (Figure 55).
Breadcrumbs appear in various forms, and the implementation depends on the genre and fiction of the game. For example, *Dead Space 2* (Visceral Games, 2011) was found to implement breadcrumb elements to help guide the player to objectives in the same manner as *Fable 3*. However, the breadcrumb is projected as a holographic path from the player character’s mechanical suit. The implementation meant the breadcrumb element was part of the in-game fiction, changing the classification to a diegetic element (see in-game devices p.202).

It is important to note that the examples of breadcrumbs were not explicitly used to complement game sound. However, it is proposed that breadcrumbs may be used to accompany or substitute effect sounds, such as non-player character calling for help, by directing the player to the location without having to navigate by sound alone.

Figure 55 Fable III Glowing Trail Geometric Visual Indicator
5.5.3 Diegetic Elements

Diegetic elements are those that exist both in the spatial world layer and in the fictional game world. A benefit of using diegetic elements includes reducing the risk of breaking immersion by utilising in-game environments and objects to convey information (Fagerholt & Lorentzon, 2009). Diegetic elements included:

- Head-up display;
- Signifiers and subliminal cues;
- Lighting;
- Particle systems;
- Avatar signing and expressive body language; and
- In-game devices.

Figure 56 Diegetic Element of the Visual Feedback Classification Model
5.5.3.1 Head-up Display

In the literature review, HUDs were identified as being strictly non-diegetic. However, the observations of video games determined there are exceptions where the HUD is incorporated into the fictional game world. These HUD elements exist in the spatial game layer of the VGUI. For example, in Respawn Entertainment’s (2014) multi-player, first-person shooter Titanfall, the player’s HUD is explained through the game’s narrative. Players pilot large mechanical robots, and the HUD is displayed as the instruments from inside the cockpit (Figure 57).

![Titanfall HUD](image)

Figure 57 Titanfall HUD (Respawn Entertainment, 2014)

Further, diegetic HUDs may also incorporate other non-diegetic elements. For example, directional markers may be incorporated to indicate the direction of waypoints and points of interest, such as enemy locations. This approach was found to be employed in video games which use vehicles. For example, in No Man’s Sky (Hello Games, 2016), a science-fiction space survival game, the player pilots space craft through various solar systems in a procedurally generated galaxy. A player’s objectives, waypoints and targets are indicated by directional markers, with unique icons to differentiate the type of marker. These markers appear in the cockpit of the space craft, explained in the game fiction as
projected holograms. In certain instances, such as the presence of a new enemy encounter, the
waypoint will also be accompanied by an *effect* sound.

Due to the informative nature of the HUD it was proposed, by this researcher, that a diegetic HUD
has the potential to be used to complement or substitute:

- *interface* sounds, such as completing an objective;
- *zone* sounds, such as showing the time, temperature, or weather conditions; or
- *affect* sounds, indicating urgency or state of the player’s environment.

### 5.5.3.2 Signifiers and Subliminal Cues

According to Fagerholt & Lorentzon (2009), signifiers and subliminal cues “provide the player with
subtle informational cues for the player to interpret by logical reasoning” (p. 52). These elements were
observed in observations of video games, and found to be frequently implemented using colour coding
and imagery. In addition, the elements are often grounded in semiotic theory, classified as:
• Indexical signs, which are those which bear a direct link to what the sign refers to (Darrodi, 2012). Examples include smoke to signify fire; balloons and streamers to signify celebration; or a pool of blood to signify danger;

• Iconic signs, which have a close resemblance to what they are representing, and serve as a referent (Darrodi, 2012). Examples including informative or directional signs, such as the image of skull and crossbones to indicate death or danger; and

• Symbolic signs, which are abstract images given meaning only through cultural convention. Typically, these signs are recognisable only by those familiar with the culture (Darrodi, 2012). For example, a red and white plus symbol indicating a health pickup in Team Fortress 2 (Figure 59) (Valve Corporation, 2007) is provided meaning due to the cultural association with the International Red Cross Society ("The emblem," n.d.).

![Health Pickup from Team Fortress 2](image)

Figure 59 Health Pickup from Team Fortress 2 (Valve Corporation, 2007)

Colour coding is another frequently utilised signifier, used to connote a thought or feeling. In video games, the colours red and green are commonly implemented to denote the alignment of a non-player character, or signify if an area can be accessed or is safe to enter.
In *Wolfenstein: The New Order* (MachineGames, 2014), red lighting above a door signifies when a door is locked, and will change to green after the door unlocks (Figure 60). This change in colour accompanies an *effect* sound of the door unlocking. Similarly, in *Titanfall* (Respawn Entertainment, 2014), enemy and friendly pilot 3D models are similar in appearance, but can be distinguished by the colour of their visor: red for enemy pilots, and blue for friendly pilots.

![Figure 60 Wolfenstein: The New Order Locked vs Unlocked doors](image)

Fagerholt and Lorentzon (2009) provide a similar example for *BioShock* (2K Boston, 2007, cited in (Fagerholt & Lorentzon, 2009)). Lights on the helmet of a non-player character, called a Big Daddy, are used to signify the character’s alignment—“either red (hostile and will attack the player), yellow (hostile, but will not attack unless provoked or triggered) or green (friendly and will protect you from attacks)” (p. 45).

Colour coding may also be utilised to accompany other forms of visual feedback such as subtitles and captions. Marc Laidlaw, former designer for the Valve Corporation, stated that during development of *Half Life 2* “a number of nonstandard creative choices [were made] to better match the experience of the game for deaf gamers”. This included the use of “color keying character fonts to the dominant
hues in their clothing”. The subliminal cue resulted in positive feedback from testers who were deaf or hard of hearing (M. Laidlaw, personal communication, 2015).

### 5.5.3.3 Lighting

Lighting was identified as a common visual feedback element during observations of video games. While the feedback element was not identified in literature or guidelines, observations determined lighting is often utilised to guide the player or draw attention to an objective or point of interest. For example, *Diablo III* (Blizzard Entertainment, 2012) uses coloured lighting to draw attention to entrance and exit points in an environment (Figure 61). Similarly, *Dead Space 2* (Visceral Games, 2011) utilises dynamic lighting to guide the player, through an otherwise dimly lit environment, by highlighting doorways and elevators.

![Figure 61 Diablo III- Lighting to indicate level exit/entry points (Blizzard Entertainment, 2012)](image1)

![Figure 62 Dead Space 2- Lighting points of interest (Visceral Games, 2011)](image2)

While these examples are not used in collaboration with game sound, there is potential for lighting to be utilised to substitute or complement:

- *effect* category sounds, to indicate a change of state in the game world due to player activity; or
- *affect* category sounds to indicate a change in setting or mood of the game.
5.5.3.4 Particle Systems

Particle systems are a graphical effect, used for “effects like moving liquids, smoke, clouds, flames and magic spells … used to capture the inherent fluidity and energy” ("Particle Systems," 2016). These visual feedback elements were not identified in existing literature, and were identified during observations of video games. For example, in Diablo III (Blizzard Entertainment, 2012) particle effects are displayed in addition to an effect sound. This includes when a skill or ability is activated, such as a magical spell. Skills and abilities can be used by both the player and non-player characters, each with their own sounds from the effect sound category. The use of unique particle effects for different abilities allows the player to distinguish those abilities based on the visual appearance alone.

![Diablo III - Spell particle effect](image)

Similarly, particle effects are used in Minecraft (Mojang, 2011) for a variety of feedback types. For example, unique particle effects were identified for:

- explosions of small and large monsters;
- weather and environmental effects;
- magically enchanted weapons;
• magic spells and potions;
• effects on player and non-player characters such as poisoning (Figure 64); and
• for depicting the emotion of non-player characters.

![Figure 64 Minecraft- poison particles (Mojang, 2011)](image1)

![Figure 65 Minecraft- water particles (Mojang, 2011)](image2)

In addition, the gameplay requires players to mine the landscape to gather materials for construction. This often results in underground excavation to create extensive mines to unearth resources. However, if the player digs under a body of water or lava, *effect* audio feedback is provided to indicate to the player that they are tunnelling too close by a dripping sound. The audio feedback is accompanied by either a blue particle effect for water, or red particle effect for lava (Figure 65).

### 5.5.3.5 Avatar Signing and Expressive Body Language

The use of avatar signing in video games is uncommon. This section acknowledges the future potential for sign language to be implemented as a diegetic element for video games based on recommendations in "Game Accessibility Guidelines" (n.d.). The guidelines state that “sign language is not seen in games, but it is another valid means of communicating information to people who have no /impaired hearing” (“Provide Signing”, para. 1). Further, the guidelines bring attention to the fact that “sign
language is highly localised… with separate localised signing required for BSL, ASL and AUSLAN (British, American, Australian)” ("Game Accessibility Guidelines," n.d., "Provide Signing", para. 2).

The claims for lack of examples for implementation were verified by observations of video games conducted in this research during the Look stage. Only one example of sign language was identified in gameplay videos for Tacoma (Fullbright, n.d.), a video game which had not yet been released when this research was conducted. The preview videos for the game demonstrate the player character using ASL for communication, including entering passcodes. However, non-player characters did not use signing in the videos, and sign language appeared to serve as an aesthetic rather than functional purpose (IGN, 2016).

![Use of ASL in Tacoma](image)

Figure 66 Use of ASL in Tacoma (Fullbright, n.d.)

With the increase in graphical fidelity of character models, body language and facial expression may be used as a visual feedback element in video games. BioShock Infinite (Irrational Games, 2013) is one such example. An allied non-player character, who accompanies the player through much of the game story, depicts emotion relating to the story and specific situations. Emotions that are expressed by the character’s facial animations include curiosity, content, anger, frustration, excitement, curiosity and fear (Figure 67).
L.A. Noire (Team Bondi, 2011) is an action-adventure game, where the player assumes the role of a detective. As part of the role, the player interrogates suspects to solve crimes. Interrogation allows the player to ask questions, and gauge the suspect’s emotions and whether they are telling the truth. The player makes these decisions based on verbal responses, facial expressions and body language (Figure 68). The high level of graphical fidelity, and use of subtitles, allows the player to participate in these interrogations without the need for effect sound.
5.5.3.6 In-game devices

In-game devices include any game object, that exists in both the fictional and physical game world, used to provide the player with either explicit or implicit feedback. For example, *Halo 4* (343 Industries, 2012) (Figure 70) informs the player of the amount of ammunition remaining in their currently equipped weapon via a display mounted on the gun in the spatial game environment.

![Figure 70 Diegetic ammunition counter in Halo 4 (343 Industries, 2012)](image1)

![Figure 71 Diegetic watch in Stranded Deep (Beam Team Pty Ltd, 2015)](image2)

*Stranded Deep* (Beam Team Pty Ltd, 2015) requires the player to source food, water and shelter while stranded on an island. Information related to the player’s health, hunger and thirst is displayed via the character’s digital watch (Figure 71). A similar implementation is used in *L.A. Noire* (Team Bondi, 2011), with all information related to the player’s objectives and case notes displayed in a note-book (Figure 69).

*Dead Space 2* (Visceral Games, 2011) has been developed to ensure all forms of visual feedback are represented in the spatial layer as a diegetic element. For example, first or third person games traditionally utilise a HUD to provide information such as the player’s health and ammunition count.
However, in Dead Space 2 the player’s health, oxygen, and stasis (energy) levels are displayed as part of the player character's 3D model in the spatial layer (Figure 72).

![Figure 72 Dead Space 2 in-game device elements (Visceral Games, 2011)](image1.png)

In addition, *Dead Space 2* (Visceral Games, 2011) incorporates other forms of feedback into the diegetic category, such as breadcrumbs. Unlike the spatial breadcrumb element, diegetic breadcrumbs exist in both the spatial and fictional game space, and can be ‘seen’ by the player character. The breadcrumb is explained narratively, as part of an in-game device element. The breadcrumb trail is projected as a hologram from the player character’s suit, directing the player to their next objective. Holograms are
also utilised to incorporate other visual feedback elements into the diegetic space. Elements which are traditionally reserved for non-diegetic menu interfaces, such as the load/save game menu and player inventory (Figure 73), are projected in the spatial game environment from a holographic projector in the player’s suit.

### 5.5.4 Meta Elements

Meta elements (Figure 74) are visual elements that exist in the fictional game world, but are not visualised in the spatial layer of the VGUI representation (Figure 34). According to Fagerholt and Lorentzon (2009), the use of meta elements “makes up for the broken perceptual link that occurs when a player is linked to a virtual avatar” and “conveys information about ones in-game internal status” (p. 52). The internal status may include the player character’s health and wellbeing, emotion or senses. In addition, these elements may reside in the filter or overlay layers as screen filters. Identified meta elements include:

- Screen-filters; and
- In-game devices.

![Figure 74 Meta Element of the Visual Feedback Classification Model](image-url)
5.5.4.1 Screen Filters

Screen filters are visual effects, such as image distortion or filtering. These visual elements appear in the filter layer, superimposed over the spatial layer, of the VGUI representation (Figure 34). Fagerholt and Lorentzon (2009) refer to these types of elements as meta-perception, stating that they are suited for “connecting to the player’s senses rather than conveying information with a high degree of detail” (p. 74), as they do not include informative text or symbols.

*BioShock Infinite* (Irrational Games, 2013) employs a non-diegetic HUD in the overlay layer. The HUD displays the player’s shield and health, and the relevant meter becomes highlighted when the player incurs damage. The shield mechanic prevents the loss of health, surrounding the player with an invisible barrier. When damaged is received, the shield depletes and, once exhausted, the player’s health becomes vulnerable which is indicated by an effect category sound of shattering glass. In addition to the effect category sound, a screen filter is activated which appears as shattered yellow glass, indicating the shields have been depleted (Figure 75).

![Figure 75 BioShock Infinite Shield Filter (Irrational Games, 2013)](image)
Similar filters were identified during observations of several video games often employed to depict feeling or emotion. For example, *The Elder Scrolls V: Skyrim* (Bethesda Game Studios, 2011) employs a blur filter when the player character is intoxicated (Figure 76). Filters are also used to depict the symptoms the player character may be experiencing because of damage or exposure to magic, and accompany *effect* sounds.

![Figure 76 The Elder Scrolls V: Skyrim Screen Filter (Bethesda Game Studios, 2011)](image1)

![Figure 77 The Last of Us Snow Filter (Naughty Dog, 2013)](image2)

Screen filters were also identified for depicting environmental and weather effects. For example, *The Last of Us* includes levels with various weather effects such as rain, snowfall and blizzards. As the player navigates these areas, *zone* sounds are used to inform the player of the weather, such as wind and rain sounds. In addition, visual effects are applied to the filter layer, to depict the same information, such as a frost filter when walking through a blizzard. *Rise of the Tomb Raider* uses similar filter elements to depict environmental effects. When navigating different environments, *zone* sounds are used to alert the player to rain and waterfalls. In addition to the sounds, filters are used including water droplets appearing on the filter layer of the VGUI representation (Figure 34).
While filters were identified as being predominantly used in first and third person perspective games, similar effects were also identified in other genres to denote a sense or feeling. For example, *Diablo III* applies a grey scale filter when the character nears death, draining the spatial world layer of all colour.

### 5.5.4.2 In-game devices

Meta in-game device elements are similar to diegetic in-game devices. While these visual elements are part of the game’s fiction, they do not exist within the spatial game world layer in the VGUI representation (Figure 34). These elements are used to provide highly detailed information, within the context of the game’s narrative. An example may include a book the player carries which contains mission objectives. However, when the book is ‘read’ the device is presented in the overlay layer, external to the spatial game world.
5.6 Second Iteration - Act

The second iteration of Cycle 2 was informed by findings in the first iteration. This included the use of:

- a new visual feedback classification model (Figure 35) to identify visual video game feedback elements; and
- the IEZA model (Fagerholt and Lorentzon, 2009) to identify corresponding audio feedback categories.

These findings were collated, refined and documented to populate the new table of feedback types (Table 15), which was developed during Cycle 2, iteration 2. The final output was the new game feedback model (Table 19), which depicts the individual visual feedback elements and interrelationships between specific game audio feedback categories.

<table>
<thead>
<tr>
<th>UI Element</th>
<th>Game Audio Feedback Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Identified via Video Game UI Component Model)</td>
<td>Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Effect (Activity)</td>
</tr>
<tr>
<td>Non-Diegetic</td>
<td></td>
</tr>
<tr>
<td>HUD</td>
<td>✓</td>
</tr>
<tr>
<td>Directional marker</td>
<td>✓</td>
</tr>
<tr>
<td>Subtitles</td>
<td>✓</td>
</tr>
<tr>
<td>Close Captioning</td>
<td>✓</td>
</tr>
<tr>
<td>Avatar Overlay</td>
<td>✓</td>
</tr>
<tr>
<td>Diegetic</td>
<td></td>
</tr>
<tr>
<td>HUD</td>
<td>✓</td>
</tr>
<tr>
<td>Signifiers and Subliminal Cues</td>
<td>✓</td>
</tr>
<tr>
<td>Lighting</td>
<td>✓</td>
</tr>
</tbody>
</table>
This is significant for this research, for academia, and the wider game development community as it identifies the individual visual elements used in video games. Identification and classification of the visual elements used in multiple genres of video games had not previously been attempted. In addition, the identification of the relationships between visual elements and categories of game sounds is new territory, and addresses gaps in existing research and industry guidelines. These findings provide a new foundation for this research and future academic research, and resulted in the completion of the second iteration of Cycle 2. Consequently, the results from the first and second iteration informed the third, and final, iteration for Cycle 2.

During the analysis of visual elements in video games it became apparent that the most frequent form of visual feedback, intentionally implemented for hearing accessibility in narratively driven games, was in the form of subtitles and closed captions. In addition, it was discovered that there is no internationally accepted standard, or definition, for captions or subtitles in video games. The non-standardisation was found to have impeded appropriate implementation and resulted in gamers voicing their criticisms via online web discussion forums. These findings were in line with the literature review (see Chapter 2.9), where subtitles and captions were found to be the most commonly cited
means of inclusive game design for the DHH. However, data on the usage and opinions of the textual form of feedback were found to be limited. As one of the key characteristics of action research is participation, this Act cycle identified the need for a third iteration, and planned to conduct a survey. The purpose of the survey was to:

- identify forms of feedback not identified during the analysis of literature and observations in Cycle 2, iteration 2;
- validate findings in the first and second qualitative data collection iterations of this cycle; and
- determine use and opinions of feedback types including subtitles and closed captions.

Questions were designed based upon findings in this cycle, and are presented in Appendix C.

**5.7 Third Iteration - Look**

The third iteration of Cycle 2 used a survey for data collection, which was planned and designed in the Act stage of the second iteration. The survey employed a snow-ball sampling method, by inviting participants to complete the survey through online social networks. Social networks included Facebook, Twitter and LinkedIn, using the researcher’s personal and professional accounts. While Twitter and LinkedIn posts were published publicly, to attract participants from the wider community, specific Facebook online community groups were also invited to participate, including:

1. Deaf PC Gamers ("Deaf PC Gamers" n.d.);
2. Deaf Gamer’s Network ("Deaf Gamer's Network," n.d.);
3. Deaf Gamer Station ("Deaf Gamer Station," n.d.);
4. Deaf XBOX Gamers ("Deaf Xbox Gamers," n.d.);
5. NZ and AUS Gaming Community ("NZ & AUS Gaming Community," n.d.);
6. Parents of Hearing Impaired Children ("Parents of Hearing Impaired Children," n.d.); and

7. Let’s Make Games ("Let’s Make Games," n.d.).

Members of these community groups were encouraged to ‘share’ the post with their contacts. This was to encourage the snowball sampling method employed.

When first visiting the website, the participants were presented with a Letter of Consent (Appendix B & D), which outlined the following:

- Purpose of the study
- Link to download an information letter (Appendix B)
- Contact details for the researcher, supervisory team, and independent Research Ethics Officer
- Statement of ethics approval

The information letter was provided in a downloadable PDF format, and outlined:

- The background to the research
- Stages of the research
- Information regarding participant recruitment
- Expectations of the survey
- Participant rights, including withdrawing consent and confidentiality
- Information regarding potential risks and benefits
- Contact details of the researchers, supervisory team, and independent Research Ethics Officer
- Statement of ethics approval
The survey ran for four weeks, and concluded after 100 responses had been received. On completion, reports were generated from within the Qualtrics survey software in PDF format. The questions for the survey were designed as part of planning in the *Act* stage of the second iteration for this cycle, and discussed in detail in Appendix C.

### 5.8 Third Iteration - Think

#### 5.8.1 Participants

The survey captured 103 recorded responses. However, 11 of those responses were incomplete and 5 participants indicated they were under the age of 18, but did not have parent or guardian consent. The 16 participants’ responses were omitted from the reporting, resulting in the number of participants used for analysis totalling 87 (Table 20).

<table>
<thead>
<tr>
<th></th>
<th>103</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responses</td>
<td></td>
</tr>
<tr>
<td>Incomplete Responses</td>
<td>11</td>
</tr>
<tr>
<td>Underage with no consent</td>
<td>6</td>
</tr>
<tr>
<td>Total used for analysis</td>
<td>103-11-6 = 87</td>
</tr>
</tbody>
</table>

The 87 participants consisted of 63 males, 21 females, 2 other, and 1 who preferred not to answer the question. Participants were aged between 5 to 64 years of age, with the majority aged between 25 to 34 years (54.65 percent), and 15 to 24 years (31.40 percent). 2 participants were between the ages of 5-15 years with parent/guardian consent. 55 participants were in Australia, 7 in the United States of America, 6 in New Zealand, and 6 in the United Kingdom. The remainder of participants were in Mexico, Canada, Czech Republic, Germany, Italy, Netherlands and Pakistan. 11 participants noted that they had been employed in the video game industry. The participants 15 years of age and under were in Australia.
5.8.2 Gaming preferences

Many participants indicated they played video games more than once a week with 32.56 percent playing 2-3 times a week, and 53.49 percent playing every day (Figure 79). 50 percent of participants aged 15 years and under played games every day, and 50 percent played games once a week.

Figure 79 Responses to ‘How often do you play video games?’

In relation to how often the participants played games on specific video game hardware platforms (Figure 80):

- more than 60 percent played PC games often or all the time;
- 40 percent of participants played mobile games often or all the time;
- 46 percent played Xbox One, PlayStation 4, and WiiU often or all the time; and
- approximately 10 percent of participants played games on handheld consoles, such as the Nintendo DS/3DS/2DS or PlayStation Vita.
Figure 80 Participant usage statistics for video game platforms

5.8.3 Subtitles and Closed Captions

When asked whether they were aware of the differences between subtitles and closed captions, almost 55 percent of participants indicated that they were aware of the differences (Figure 81). Most of those were in countries where there are current standards or definitions for captions for other forms of media, such as Australia, Canada or the United States of America. However, given that many participants were in Australia and the United States, it is unknown whether this was a contributing factor. Further, of the participants who noted that they have been employed in the games industry, 46 percent of those were not aware of the differences between captions and subtitles.
Regarding subtitle usage (Figure 82), 61 percent of all participants indicated they actively enabled subtitles when playing games. 23 percent said they would leave them on by default, while the remaining 16 percent would not enable subtitles, or would turn them off. 100 percent of participants under the age of 15 indicated they never use subtitles.

Of those who indicated they use subtitles when playing video games (Figure 83):

- 5.5 percent of participants indicated they had a form of hearing loss;
• 73.3 percent of respondents said they used subtitles as they did not want to miss crucial information;

• 56 percent said subtitles helped them understand dialogue that is overpowered by music or sound effects; and

• 50.67 percent said they used subtitles to assist when a character speaks too quickly.

![Figure 83 Participant responses for using subtitles](image)

9 respondents also provided a textual response for subtitle usage:

• “I enjoy reading the story as text, more than hearing it”

• “At times it can get quite noisy in my neighbourhood and becomes hard to hear what the characters are saying, so I turn on subtitles”

• “Identifying fictional names”
• “Im [sic] usually watching movies or tv while playing games using 2 monitors and play most games with the sound off. I use subtitles to keep up with what is going on”
• “Constant stream of interruptions while playing”
• “Yi [sic] can read faster than speech”
• “I may be voicechatting [sic] or listening to music, which can obscure unexpected speech”
• “Because why not?”

![Figure 84](image.png)

Figure 84 Reasons for not using subtitles

16 percent of all participants indicated they did not use subtitles (Figure 84). Of those:

- 43 percent noted they found subtitles to be a distraction;
- 36 percent had no experience with captions influencing the lack of use;
- 21 percent of participants stated that the games they played did not use dialogue, or they were too busy playing the game to take the time to read subtitles; and
- 14 percent of respondents indicated that subtitles were not available in the games that they play, or they found them difficult to read.
This included 100 percent of participants between the ages of 5 and 15, who indicated they did not use subtitles as they found them difficult to read.

3 textual responses were also provided, stating:

- games “feel less immersive with subtitles”;
- they “don’t need them”; and
- that they won’t use subtitles “unless it’s in a foreign language”.

The results of players who use closed captions in video games was vastly different from those who use subtitles (Figure 85). 60 percent of respondents indicated they had never used closed captions, 25 percent left them on by default, and 15 percent actively turned captions on. 100 percent of participants between the age 5 and 15 said they have never used captions in video games.

![Figure 85 Closed caption usage](image)

Of the respondents who selected that they use closed captions, 9 percent said it was due to a hearing loss or because English was a second language. A large proportion of respondents selected choices related to understanding information. This included:
53 percent of respondents who use closed captions to ensure they don’t miss any crucial information;

21 percent to help them to understand the story; and

35 percent due to playing in a sound sensitive environment.

Figure 86 Participant reasons for using closed captions

The results for question 9, from participants who indicated they did not use closed captions (Figure 87), showed that 62 percent had never used them before. Textual responses provided additional information, including participants stating:

- they found captions “too excessive”;
- they “can always hear well enough to discern sound effects”;
- they “don’t feel likely to miss any information by leaving them off”; and
- they “weren’t aware” that captions existed.
Figure 87 Participant reasons for not using closed captions

Of the results from question 10, regarding participant’s experiences with subtitles and captions (Figure 88), 68 percent said that subtitles were available in their games often or all the time. 7 percent said that they were never or rarely available in their games. Of those who indicated that subtitles were not available, their primary platforms for video games were mobile gaming devices. For participants between age 5 and 15 years:

- 50 percent said subtitles were never available in the games they play, and 50 percent said subtitles were sometimes available;
- 50 percent said subtitles never helped them play games, and 50 percent said subtitles sometimes help them play games;
- 100 percent of participants never found games more enjoyable with subtitles or captions enabled.
In relation to caption availability for all participants, 15 percent of participants said that closed captions were available often or all the time in games that they played. 75 percent found that captions were available rarely or only sometimes. Of those who selected often or all the time, the preferred platforms for those participants were handheld games, PC games and home consoles. Based on these results, it can be determined that subtitles and captions are least likely to be available on mobile devices. Further, participants who had previously indicated that they use subtitles or captions due to a hearing impairment noted that subtitles and closed captions helped them to play games. In addition, those participants found games more enjoyable when using them.

Most participants’ preferences were towards subtitles rather than captions (Figure 89). Approximately 50 percent of participants indicated that subtitles helped them to play games, and made their experience more enjoyable. 15 percent believed that closed captions helped them while playing games.
and provided a more enjoyable experience. It should be noted that only 15 percent of participants stated closed captions were available in the games that they play, and those same participants indicated that captions helped them to play games and made them more enjoyable. This did not include participants under the age of 15 years, who stated captions were never available in the games they played. In addition, if subtitles were available in the games they played they did not aid in improving user experience, as participants found them difficult to read.

Figure 89 Opinions on subtitles, captions and standards.

On reflection, an initial explicit question to indicate whether the participant experienced a hearing loss may have been beneficial. While the response option “I have a hearing loss” existed for the questions asking why subtitles and captions were used, there was no way to determine whether participants who experience a hearing loss did not use subtitles or closed captions, or to identify whether they had a preference of subtitles over closed captions.
Question 13 related to participant’s opinions of closed captions and subtitles, and partially addressed the issue. 65 percent of participants noted that they agree or strongly agree with a preference towards subtitles rather than captions. 23 percent of participants were undecided, and 12 percent preferred captions over subtitles. All participants who had previously indicated they experienced a hearing loss, in response to question 12 and/or 15, preferred captions over subtitles.

Regarding whether participants believed there needs to be a standard for subtitles and captions, 55 percent agreed or strongly agreed, while 28 percent were undecided. 20 percent of respondents disagreed or strongly disagreed with the need for a standard. Further, 67 percent of participants chose to agree or strongly agree with the need for subtitles to be a mandatory option in video games, while 50 percent shared the same opinion for closed captions.

Finally, almost 50 percent were undecided on whether they would like to see different ways of conveying information, other than audio, in video games. 9 percent disagreed or strongly disagreed, and 41 percent agreed or strongly agreed. Of those who agreed or strongly agreed, all of those had previously indicated that they had a hearing loss in response to questions 12 and/or 15.
For participants who indicated they were employed in the video game industry (Figure 90) opinions on the use of subtitles and captions were greatly varied. In relation to whether subtitles should be mandatory in video games:

- 65 percent agreed or strongly agreed;
- 9 percent undecided; and
- 26 percent disagreed or strongly disagreed;

The final two questions of the survey were related to the participant’s knowledge of additional methods of conveying information that is traditionally depicted through game sound. The question was multiple choice, with a yes or no answer. If respondents chose yes, they were asked to provide additional information. 8 participants indicated that they knew of other in-game options, and provided a single word or a short sentence response. These included:
• 2 respondents describing a form of haptic or tactile feedback;
• 2 providing examples of music of rhythm games;
• 1 providing an empty response;
• 3 participants referring to visual forms of feedback:
  o Participant four: Flashes of colour or light to draw attention;
  Participant 4’s response fits the previously categorised spatial element silhouettes, outlines and focus highlights (see p.188), or the diegetic element lighting or particle systems (see p.197).
  o Participant 5: Screen-shake and visual cues using HUD or environment;
  Of the two examples provided by participant 5, the screen shake example did not fit within a predefined element in the game feedback model. It was intended to investigate this further in the Act stage of this cycle. Participant 5’s suggestion for visual cues using the HUD or environment was found to lack specificity, but it was expected that the HUD visual cues would fall under the non-diegetic and diegetic HUD elements classified in the second iteration of this cycle. Environmental visual cues may refer to elements such as those classified in the spatial and diegetic element categories.
  o Participant 8 provided a detailed response, providing the following statement:
    “In stealth games (Dishonored for example) when a character goes into hiding, the sound they’re making and the sound others make are presented visually as circular waves coming from their point of origin. Although I think this is unique to this game genre”

It was determined that the form of feedback the participant referred to is the same as what had been previously classified as a spatial element. Similar examples were identified in Geometric Contextual Icons and Text, where sonar icons were used to identify the source of sounds originating from NPCs.
The final survey question was formatted as an open-ended question. The question provided participants with the option to provide additional comments or questions about the survey, or topics related to the survey. 13 participants provided comments, including comments related to the survey design and opinions of subtitles and closed caption usage in games:

- 7 participants stated that they felt that subtitles and/or closed captions should be mandatory.
  - 4 stated that there should be additional options in games to control whether the content is solely for dialogue or for all informative sounds.

- 1 participant stated that video games should be required to provide additional options to adjust font, size, colour and background for subtitles and closed captions; and

- 2 participants provided comments on the survey design.

Of interest was a comment provided by participant 4, which stated:

Some of the questions required extra options, as they are too black and white. For example, the question “Do you use subtitles[sic] in the game[sic] you play (there is no option for Sometimes). While for the questions like “Subtitles/Closed Captioning are available in the games I play”, there is no opportunity to say I don’t know (which many hearing people won’t).

Another participant reiterated this point stating:

Some of the questions need a few extra answers, for example it ask[sic] how useful I found[sic] CC but as I never used them I cannot answer in a useful way.
These responses draw attention to limitations in the survey design. They also bring into question whether the opinions of closed captions are an accurate reflection of people’s opinions or experiences, given that some of the participants may have not had any prior experience with closed captions.

Finally, two participants, who had previously indicated they had been employed in the video game industry, provided vastly different opinions on the use of subtitles and captions. The first stating: “Developers should be able to decide which audience they’d like to target/include. It costs time and money to add subtitles and closed captioning, this is my opposition to making subtitles mandatory. It’s not always economically viable.” The second participant provided a similar opinion “It’s not Video Games’ job to force subtitles into games. If there’s a financial benefit to putting subtitles in, then they will naturally make their way in.”

These responses are not dissimilar to what had been identified in the literature review. It was identified that some game developers believe that progress is hindered by negative opinions towards accessible design. However, as previously identified, there are a number of benefits to inclusive design, including increased revenue, media attention, and encouraging creativity. It is suggested that perhaps additional awareness is required to develop better understanding for game developers (Moss, 2014; Powers et al., 2015; Zahand, n.d.).

It is important to note that this survey did not serve for statistical analysis. The purpose and core knowledge of this survey data was used to confirm findings from the literature review. This included information related to opinions and usage of video game accessibility features, and the different forms of feedback used as an alternative to game audio.
5.8.4 Summary of Analysis

From these results, it can be surmised that most participants agreed on the importance of subtitles and closed captions in video games. Participants’ responses provided evidence to support the claim that the textual forms of feedback are not used solely by people who are deaf or hard of hearing, or for translation purposes. Subtitles are frequently used to improve the gaming experience for the general gaming community. These results are in line with findings from the literature review and the second iteration of cycle 2, where potential benefits for inclusive design include improving user experience for the abled gaming population, in addition to those with special needs (Hamilton, 2015; Moss, 2014; Powers et al., 2015; Zahand, n.d.).

There were few responses from participants aged 15 years and under. All participants between five and fifteen years of age indicated that they did not use subtitles or captions in video games. This was due to the fact they found them difficult to read. These results are in-line with findings from the literature review, where textual forms of feedback were deemed unsuitable for children, due to difficulties with reading comprehension. It is important to note that the sample size of participants, fifteen years and younger, is small and may not be an accurate representation to provide sufficient statistical validity.

5.9 Third Iteration – Act

In the survey, a game camera visual feedback element was identified that was unable to be classified using the new visual feedback classification model (Figure 35) or the new video game user interface (VGUI) representation (Figure 34). Consequently, the element could not be entered in the game feedback model (Table 19). The detailed textual response provided an example relating to the manipulation of a game camera to provide an alternative form of feedback to game audio. This issue
required further investigation to address the gap in the classification methods, and revision of the associated models.

The game camera is “typically fixed to display game-relevant actors and action” (p. 126), with the perspective relative to the genre. For example:

- A first-person camera offers “a view through the player character’s eye” (p. 126); and
- A third-person camera is typically “fixed … at a specified distance away from the game characters and following his or her movements through the game” (Thorn, 2012, p. 126)

Further investigation determined that visual effects, such as the screen shaking effect, are often applied to a game’s camera to provide visual feedback. One such method uses Perlin Noise to give the effect that the spatial game world is shaking or moving, and typically accompanies an effect sound such as an explosion, monstrous footsteps and earthquakes (KOKOStern, 2014). Alternative forms of camera manipulation include zooming in on areas of interest, or providing the option for a player to focus on an area of interest using a button press. For example, in *Gears of War III* (Epic Games, 2011) a point of interest in the environment is brought to the attention of the player with an interface sound, and an eye and button icon shown as a non-diegetic element in the HUD (Figure 91). If the player presses the corresponding button, the game camera automatically repositions itself to focus on the point of interest. Similar examples were identified in video games including *The Last of Us* (Naughty Dog, 2013), *Tomb Raider* (Crystal Dynamics, 2013), and *L.A. Noire* (Team Bondi, 2011). These elements were identified as being used for effect, affect, interface and zone sounds.
Based on these findings, the layer descriptions for the VGUI representation were redefined as follows:

- The **Spatial Game Space** layer represents the physical game world, and any visual element that is represented within the spatial game space. This is a mandatory component for a video game with a visual user interface.

- The **Filter** layer is imposed over the spatial game space, used for the application of imposed visual elements outside of the game world. These elements do not provide detailed information, and instead consist of visual effects like filters in cinematography. Elements may consist of colour, blur, and grain filters, fading or other graphical elements such as frost or water droplets. The filter layer is an optional element of a VGUI.

- The **Overlay** layer of the VGUI model represents a camera, window, or viewport into the spatial game world from the player’s perspective. The perspective includes, but is not limited to, first-person, third-person, top-down and side-scrolling. As such, the overlay layer is a mandatory component of a VGUI. The overlay layer also includes any other visual effect that is superimposed over the Spatial Game Space and Filter layers which are not directly impacted by camera movement, such as a non-diegetic HUD.
The amendments were not found to have an adverse impact on the existing classification of elements in the game feedback model. However, the revised definition of layers did permit the classification of the camera shaking effect identified in the survey results, and similar camera manipulation techniques identified in subsequent analysis of video games. Based on these findings, the camera manipulation element was added to the meta elements category in the game assessment framework (Table 19).

Table 21 Populated game feedback model

<table>
<thead>
<tr>
<th>UI Elements (Identified via Video Game UI Feedback Model)</th>
<th>Game Audio Feedback Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Non-Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Effect (Activity)</td>
</tr>
<tr>
<td></td>
<td>Zone (Setting)</td>
</tr>
<tr>
<td></td>
<td>Interface (Activity)</td>
</tr>
<tr>
<td></td>
<td>Affect (Setting)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-Diegetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUD</td>
</tr>
<tr>
<td>Directional marker</td>
</tr>
<tr>
<td>Subtitles</td>
</tr>
<tr>
<td>Close Captioning</td>
</tr>
<tr>
<td>Avatar Overlay</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Diegetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUD</td>
</tr>
<tr>
<td>Signifiers and Subliminal Cues</td>
</tr>
<tr>
<td>Lighting</td>
</tr>
<tr>
<td>Particle Systems</td>
</tr>
<tr>
<td>Avatar Signing</td>
</tr>
<tr>
<td>In-game Devices</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spatial</th>
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</thead>
<tbody>
<tr>
<td>Geometric Indicator (icon, text etc.)</td>
</tr>
<tr>
<td>Silhouette, Outline &amp; Highlighting</td>
</tr>
<tr>
<td>Breadcrumb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Meta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Filter</td>
</tr>
<tr>
<td>In-game devices</td>
</tr>
<tr>
<td>Camera Manipulation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 19 Populated game feedback model</th>
<th>Table 21 Populated game feedback model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect (Activity)</td>
<td>Zone (Setting)</td>
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<tr>
<td>-------------------</td>
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</tr>
<tr>
<td>HUD</td>
<td>✓</td>
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<tr>
<td>Directional marker</td>
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<td>Subtitles</td>
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<tr>
<td>Close Captioning</td>
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<td>Avatar Overlay</td>
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<td>✓</td>
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<tr>
<td>Camera Manipulation</td>
<td>✓</td>
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</table>
The findings of this Cycle answered the second subsidiary research question, which was:

**Sub. Research Question 1.2**: *What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?*

In response to the research question, there are various forms of visual elements which may be utilised as an alternative to audio to accommodate accessibility for the DHH (Table 19). These elements were categorised using a VGUI representation (Figure 34) and visual feedback classification model (Figure 35). Further, each element was analysed to determine if they were known to be suitable or potential alternatives based on critical analysis of literature and observations. Each of the identified visual elements were described in detail, with extensive examples of implementation.

As planning is a core characteristic of the *Look, Think, and Act* action research method, this *Act* stage involved planning for Cycle 3. Cycle 3 of the research was initially described as the ‘development of a potential solution’ on commencement of the research, as it was unknown what the potential solution may be. However, through findings of Cycle 1, it was determined that the potential solution would be in the form of a game assessment framework. The new game assessment framework was planned to aid in the assessment and identification of potential visual feedback elements to be implemented to complement or substitute auditory feedback in video games, using the results of Cycle 2.

Chapter 6 describes Cycle 3 of this research, and the development of the game assessment framework.
Chapter 6: Cycle 3 – Game Assessment Framework for Hearing

Accessibility

The third cycle of the research (Figure 92) describes the process taken to develop a potential solution to the research problem. Based on the results of the first two cycles of this research, a new game assessment framework was developed. Results of this cycle were used to address the primary research question for this research:

Research Question 1: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?

Cycle 3 consisted of three iterations to achieve the final solution through exploration and investigation. Key characteristics of the action research method are flexibility and responsiveness which were predominant during this cycle. Each iteration is presented as follows:

- **Look**: informed by data collected from previous cycles, to guide the development of a game assessment framework.
Think: the attempted development of a game assessment framework, using the data from in the Look stage, and analysing the results of the process.

Act: Interpretation of results from the Think stage, with results informing the planning of a future iteration. In the case of the third iteration, the Act stage served as an interpretation and summary of the findings.

6.1 First Iteration- Look

In the Look stage in this first iteration, a preliminary game assessment framework was developed based on the results of Cycle 1 and 2. The data that informed this cycle included:

- results of Cycle 1, which identified a game assessment framework as being a potential solution for guiding accessible design for the different video game design methods; and
- results of Cycle 2, with the populated game feedback model of visual feedback elements and corresponding categories of audio feedback.

Figure 93 Development of automated hearing accessibility assessment tool

Once the preliminary game assessment framework had been developed it was intended to guide the development of a hearing accessibility assessment tool in the Think stage (Figure 93). However, during preliminary development it was evident that an alternative approach was required. This was because
the hearing accessibility assessment tool lacked flexibility and specificity. This is described in detail in the *Think* stage of this cycle (6.2).

The purpose of the hearing accessibility assessment tool was for testing purposes, to determine whether the game assessment framework could produce an accurate assessment of video game hearing accessibility together with recommendations for improvement. The structure of the hearing accessibility assessment tool was planned as follows:

- a front end consisting of a web-form with questions based on the new game assessment framework; and
- a database used to store the visual feedback elements identified in the game feedback model (Table 21).

The questions in the hearing accessibility assessment tool would be used to determine what audio feedback categories and visual feedback elements were used in a video game. Based on the responses, the data would be cross-checked with potential visual feedback elements stored in the database from the game feedback model (Table 19). Results of the analysis would then be produced in a hearing accessibility report. Reports were intended to be used to assess the level of accessibility for several games which had previously been reviewed by online game accessibility websites, including D.A.G.E.R system, Game Critics, and Unstoppable Gamer ("D.A.G.E.R. System," ; "Gamecritics.com," n.d.; "Unstoppable Gamer," n.d.). Qualitative results would be compared to reviews to determine the accuracy of the tool. Once the tool was deemed to have successfully evaluated the accessibility of a video game, the results would be used to validate accuracy and credibility of the game assessment framework.
6.2 First Iteration- Think

The initial game assessment framework is represented in Figure 94. The framework process is based loosely on the process used in game accessibility guidelines, where problematic audio feedback is identified and represented in an alternative manner (Bartlet & Spohn, 2012). This process is as follows:

1. Determine if sound is used in the game
   1.1. If no sound is used, the game does not require additional hearing accessibility considerations and the process ends. This question was influenced by the ‘Baby-Friendly Test’ identified and discussed in the literature review (Bartlet & Spohn, 2012).

2. Each sound is categorised using the IEZA framework.

3. Determine if each sound has an alternative visual feedback element to substitute each game sound.
   3.1. If a game sound is not represented visually, identify a potential solution from the game feedback model
   3.2. If all sounds are represented visually, the process ends.

![Figure 94 Preliminary game assessment framework](image-url)
Once the preliminary framework had been developed, it was extended to guide the development of a hearing accessibility assessment tool. The first step in the development of the tool was the development of pseudocode for a front-end form, based on the steps outlined in the framework:

1. What is the title of the game? (Text input field)
2. What age group is the game targeted towards? (0-12, 13-17, 18-25 etc.)
3. Does the game include auditory feedback? (yes/ no)
   3.1. (If yes) Go to question 4.
   3.2. (if no) END

Repeat for each IEZA category:

4. Is interface/effect/zone/affect audio used? (yes/ no)
   4.1. (If yes) Go to question 5.
   4.2. (If no) Go to next sound category, or END if all categories have been evaluated

5. Enter the name of each sound used (text input)
   5.1. Go to 7

Repeat for each sound entered in Q5:

6. Is the sound presented in another form of visual feedback? (yes/ no)
   6.1. (If yes) Go to question 7.
   6.2. (If no) GET suggestions from DB for visual feedback in final report

7. What forms? (checkbox for visual feedback categories)
   7.1. Non-diegetic
   7.2. Diegetic
   7.3. Meta
   7.4. Spatial

8. Which of the following visual elements are used for the sound? (checkbox of all elements for the selected visual feedback categories).

9. Present final report, including suggestions for visual feedback from Q6 and visual feedback types to include that were not selected in question 8.
The process is represented in diagrammatic format in Figure 95.

Figure 95 Automated hearing assessment tool process
Based on the process and questions a simple front-end form was developed. However, it was immediately apparent that the solution was unsuitable for the required application of this study, since there was no means of determining which visual elements were applicable to a specific game, depending on the genre and design choices. Further investigation determined, to address these issues, the automated tool would need to account for variables such as genre, platform, target audience, cost and time required for implementation. Adding this level of specificity to the hearing assessment tool had the potential to create issues with games which do not conform to specific genres of games.

As identified in the literature review, the underlying hardware and video game software was found to be rapidly evolving. In addition, concepts such as game genre are not concrete or formally categorised. According to Konzack (2015), such an approach may never be viable, “because new genres may emerge and with every new video game, video game genres slowly or radically transform” (p. 3070). These factors had the potential to impact flexibility and generalisation of the web-tool, and it was determined an alternative approach was required.

6.3 First Iteration- Act

Based on the findings in the Think stage, the concept of a web-tool as a potential solution was discarded. It was proposed that automation of the process resulted in non-specificity, and required a human element for analysis. These findings resulted in the end of the first iteration. However, the preliminary game assessment framework, and questions developed as part of the pseudocode were retained for the second iteration.
6.4 Second Iteration – Look

The second iteration of Cycle 3 was informed by the findings of the first cycle. This included the preliminary game assessment framework and questions from the pseudocode to assess the level of hearing accessibility in a game. The findings from the first iteration were refined for use in an amended game assessment framework, and a stage for playtesting was included as user feedback was identified as an accessibility approach in the first cycle of this research and limitation of the first iteration of this cycle.

6.5 Second Iteration – Think

The second iteration of the game assessment framework was refined, with the several stages in the initial game assessment framework merged into three stages (Figure 96):

1. a **pre-assessment** stage to determine if assessment was required;
2. a **categorisation** stage to classify sounds used in a game based on the IEZA framework (Huiberts & van Tol, 2008).
3. an **identification** stage, to identify potential alternative forms of visual feedback using the game feedback model (Table 21).

The game assessment framework stages were refined as the framework was no longer being used to develop an automated hearing assessment tool, and to simplify the process to ensure ease of use. The revised game assessment framework is depicted in Figure 97. Each stage is further described in this *Think* stage.
Pre-assessment stage

The pre-assessment stage (Figure 98) of the revised game assessment framework (Figure 97) involved two questions, derived from the pseudocode used to guide the development of the intended automated hearing accessibility assessment tool in the first iteration of this cycle. The purpose of the first question was to determine whether a game used audio feedback. A game without audio feedback was considered accessible for the DHH, and did not require additional consideration.
Figure 98 Pre-assessment Stage of game assessment framework

**Question 1: Does the game use sound?**

1.1. If the answer to this question is no, no other considerations need to be made for audio accessibility.

1.2. If the answer is yes, proceed to question 2.

The second question was based on the baby-friendly test (used to determine whether a video game can be played without audio), first introduced in the Includification documentation (Bartlet & Spohn, 2012) and discussed in the literature review. This stage was to be conducted in collaboration with playtesters, to determine whether a game can be played with the sound disabled.

**Question 2: Can the game be played with the audio muted, and with no adverse impact on the game playability or user experience?**

- If the answer to this question is no, then the Categorisation of Sound Elements stage commences
- If the answer is yes, it is at the discretion of the developer to continue.
Categorisation of sound elements stage

The second stage of the game assessment framework (Figure 97) included the documentation of all the sounds used in the game, and categorisation using the IEZA framework (Huiberts & van Tol, 2008). Table 22 is an example of what a categorisation of game sounds in a video game might include. Each game sound is identified and entered in the table under the Game Sound Name column. The category of the game sound is indicated in an adjacent column. This data would then be used in the third stage of the game assessment framework (Figure 97), Identification of Visual VGUI Elements, to identify potential corresponding visual elements for all sounds used in the game.

Table 22 Initial Sound Categorisation Example

<table>
<thead>
<tr>
<th>Game Sound Name</th>
<th>Effect (Activity)</th>
<th>Zone (Setting)</th>
<th>Interface (Activity)</th>
<th>Affect (Setting)</th>
</tr>
</thead>
<tbody>
<tr>
<td>playerWalkDirt</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>playerWalkWater</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>playerWalkWood</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>playerHungry</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>playerOutOfBreath</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>playerIdleHum</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>playerIdleWhistle</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>backgroundMusic</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>menuButtonClickDown</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Identification of visual VGUI elements stage

The third stage of the game assessment framework (Figure 97) involved cross-referencing the individual sounds identified Categorisation of Sound Elements stage with the game feedback model (Table 21). For example, the playerOutOfBreath sound in Table 22 was identified as an Effect category sound. This game sound describes a sound heard when the player character is swimming under water and is running out of air. Using the game feedback model, the following potential visual feedback elements may be used as an alternative to foster hearing accessibility:
• Non-diegetic elements: HUD, directional marker, subtitles, captioning or an avatar overlay;

• Diegetic elements: HUD, signifiers, lighting, particle systems, avatar signing, body language and facial expressions, or in-game devices;

• Spatial elements: geometric indicator, silhouette or breadcrumbs; and

• Meta elements: screen filter, camera manipulation.

The list of potential visual elements provides several options for a developer to select, depending on the game genre, platform and design choices. For example, the following specific visual elements may be used for the player out of breath sound:

• facial expression or expressive body language animation, such as panic on the face of the player avatar, or flailing arms and legs. These elements would be suited in a game where the player character is visible by the player;

• camera manipulation, such as a shake;

• a camera filter, such as darkening or blurring around the edges of the screen;

• subtitles or captions of the player ‘gasping’ or [out of breath!];

• a visual indicator in the non-diegetic HUD, such as a depleting oxygen meter;

• a visual indicator in an in-game device, such as a facemask, which displays a diegetic HUD and visual indicator of the amount of oxygen remaining. These elements would be suited for a first-person game;

• a particle system, such as bubbles steadily decreasing from the character’s mouth or nose;

• a geometric indicator, such as an arrow, which flashes in the spatial environment alerting the player to swim up; or
• A signifier or subliminal cue, such as the player character’s face slowly turning blue in a game where the player’s character is visible to the player.

Whilst it was intended to analyse several video games to determine usability and comprehensiveness of the second iteration of the game assessment framework (Figure 97), critical limitations were observed which had the potential to impact the effectiveness of the framework. These factors were:

• the process was not iterative, and:
  o did not permit re-assessing a game, once a visual element had been implemented, to determine if accessibility issues had been addressed; and
  o not accounting for adaptive design, where new sounds may be added during development;

• it is common for video games to incorporate a vast library of sounds, with some mainstream video games including hundreds of individual sound clips, which had the potential to make the process of categorising every sound excessively time consuming;

• a game sound library may include multiple variations of a sound, such as footsteps on different surfaces, resulting in the unnecessary entry of multiple sounds of the same type during sound classification, increasing time required to classify sounds;

• not all game sounds are of equal importance, with some sounds having a potentially greater impact on user experience and gameplay than others;

• the process of identifying visual elements for every sound used in a video game being unnecessarily time consuming and complex; and

• The pre-assessment stage required the developer to determine whether a sound impeded user experience and gameplay for the intended target audience, without considering user feedback.
Based on these findings, it was determined that further amendments to the game assessment framework were required. This led to the end of the Think stage for the second iteration, and results of the analysis informed the Act stage. This was in accordance with the research method characteristics of responsiveness and iteration.

6.6 Second Iteration - Act

From the analysis in the Think stage of the second iteration of the game assessment framework, several factors were identified having the potential to impact effectiveness and usability. This included the realisation that not all game sounds are of equal importance, multiple sound clips being used for a similar application, the framework’s lack of iteration, and failure to incorporate user feedback to determine impact of game sound on user experience and gameplay. Based on these findings, it was planned to:

- add a new stage to determine the impact of individual sounds based upon user feedback;
- introduce a method of grouping similar sounds together;
- amend the framework to enable iteration for assessment after implementation of alternative visual feedback elements and to accommodate adaptive game design methods; and
- include user feedback as part of the hearing accessibility assessment.

In addition, it was considered critical that the framework was easy to use, and allowed developers to decide on the amount of effort they would contribute towards accessible design considerations. For example:

- a developer with limited funding or resources may decide to provide additional visual feedback only for sounds with the greatest impact on game playability and user experience; or
• a developer who wanted to achieve the highest level of accessibility may consider implementing visual VGUI elements for many game sounds.

It was anticipated this approach would also accommodate the differences of game developer’s opinions for accessible game design. As identified during the literature review and in the survey, some developers believed that accessibility is a costly, time consuming and wasted effort. Others were eager to develop accessible games for the DHH, but potentially unaware of how to approach accessible design. By providing a scale of options, it was proposed that developers could decide on the level of implementation and investment of resources, while maintaining a high-quality level of inclusiveness for the DHH.

6.7 Third Iteration – Look

The third iteration of Cycle 3 was informed by results of all previous iterations. This included limitations of previous iterations of the game assessment framework which led to the planning of a third iteration. These limitations and potential solutions were documented in Table 23 and informed the Think stage.

Table 23 Limitations and potential solutions for game assessment framework

<table>
<thead>
<tr>
<th>Limitation</th>
<th>Potential Solution</th>
</tr>
</thead>
</table>
| Games implementing a vast array of sounds, resulting in the assessment of individual sounds being excessively time consuming and complex. | • Identify a means of integrating identification of game sounds during the game design process.  
• Implement a means of only categorising sounds that have an adverse impact on gameplay or user experience. |
| Several variations of sounds may be used for a single form, of feedback. The framework provided no means of grouping those individual sounds together. | • Implement a means of grouping variations of sounds together (such as different footstep sounds for different ground surfaces). |
Sounds are not always of equal importance, nor do they all have the same level of impact on a user’s experience.

The framework not being iterative. This resulted in the pre-assessment stage being conducted again in subsequent uses. In addition, no assessment was conducted after a VGUI element was implemented to determine whether potential hearing accessibility issues had been addressed.

The pre-assessment did not include user feedback to determine the impact of game sounds on user experience or gameplay.

| Implement a means of only categorising sounds that have an adverse impact on gameplay or user experience. |
| Amend the framework process to foster both predictive and adaptive approaches to design by removing the pre-assessment stage |
| Implement an assessment of game sounds after a VGUI element has been implemented to ensure hearing accessibility requirements have been met. |
| Implement a means of including user assessment and feedback of game sounds |

### 6.8 Third Iteration - Think

Based on the findings in the first and second iterations of Cycle 3, and limitations summarised in the *Look* stage of this iteration, the final version of the game assessment framework was developed (Figure 99). The changes included three primary amendments:

1. The first revision was to remove the pre-assessment stage, which was considered redundant, as:
   - a game which did not include sounds would not require categorisation of sounds; and
   - determining whether specific sounds impeded user experience and game play was initially appraised by the developer. However, this was considered a limitation of the second iteration of the framework, and user-testing was included as part of a new assessment process.

2. The introduction of an assessment stage to prioritise the impact of individual sounds on gameplay and user experience. This stage involved user-testing, and assessment was conducted only if sounds were used in a game, and had been classified in the categorisation stage.

3. The addition of iteration:
between assessment and implementation to determine whether implemented visual feedback elements addressed hearing accessibility issues; and

- between implementation and categorisation, so any new sounds added to the game could be assessed, to accommodate iterative design.

The new game assessment framework included:

- a categorisation stage;
- assessment stage; and
- an implementation stage;

---

**Figure 99 Game assessment framework**

### 6.8.1 Categorisation Stage

The first stage of the framework (Figure 100) involved identification and categorisation of the different sounds used in the game, based on the IEZA framework (Huiberts & van Tol, 2008). Depending on the game design method, the framework may be utilised for either predictive or adaptive design methods, or for the assessment of an existing game.

---

**Figure 100 Categorisation Stage**
6.8.1.1 Predictive design sound categorisation

For predictive design, a catalogue of required game assets is typically documented prior to commencement of development. If the game utilises audio, this may also include a complete list of the different sounds required for the game, such as background music and individual sound clips. For example, the fourth stage of the DODDEL model involves development of production documentation (McMahon, 2009). The production documentation contains the game’s scripts, storyboards, flowcharts and data flow diagrams, pseudocode, visual templates, and a complete list of assets required. The assets list includes any game sounds, an ID for reference, and a description of the function of those sounds (Table 24).

Table 24 Example audio assets list used in the DODDEL Model

<table>
<thead>
<tr>
<th>ID</th>
<th>Sound Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>backgroundMusic1</td>
<td>Background music for the main menu</td>
</tr>
<tr>
<td>1.1</td>
<td>backgroundMusic2</td>
<td>Background music for the first level</td>
</tr>
<tr>
<td>2.0</td>
<td>buttonClickDown</td>
<td>Click sound effect used for buttons in the menu interface.</td>
</tr>
</tbody>
</table>

In the case of using the DODDEL model for the predictive development of a game, the IEZA sound classification may be integrated into the production documentation. This would require minimal adjustment to the design process. For example, Table 25 depicts example sounds found in a game, and their classification:

Table 25 Example assets list with sound classification in the DODDEL Model

<table>
<thead>
<tr>
<th>ID</th>
<th>Game Sound Name</th>
<th>Effect (Activity)</th>
<th>Zone (Setting)</th>
<th>Interface (Activity)</th>
<th>Affect (Setting)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>playerWalking1</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Player walking on grass</td>
</tr>
<tr>
<td>1.2</td>
<td>playerWalking2</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Player walking on dirt</td>
</tr>
<tr>
<td>1.3</td>
<td>playerFallDamage</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Player character ‘ouch’ sound when falling</td>
</tr>
</tbody>
</table>
For an adaptive design method, a similar approach is taken to predictive design. However, the table becomes a living record of sounds used in the game and, as the game is progressively developed and new game sounds added, the sound classification document is updated throughout the iterative design process. In addition, the game assessment framework can be repeated throughout the development process, ensuring that feedback is suitably accessible for the DHH as the game is developed, rather than conducting a single assessment on completion.

<table>
<thead>
<tr>
<th>2.0</th>
<th>backgroundMusic1</th>
<th>✓</th>
<th>Background music for the main menu</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>backgroundMusic2</td>
<td>✓</td>
<td>Background music for the first level</td>
</tr>
<tr>
<td>2.2</td>
<td>forestAmbienceNight</td>
<td>✓</td>
<td>Ambience for the forest environment from 6pm-6am game time with crossfade with 4.1</td>
</tr>
<tr>
<td>2.3</td>
<td>forestAmbienceDay</td>
<td>✓</td>
<td>Ambience for the forest environment from 6.00am-6.00pm game time with crossfade with 4.0</td>
</tr>
<tr>
<td>3.0</td>
<td>buttonClickDown</td>
<td>✓</td>
<td>Click sound effect used for buttons in the menu interface</td>
</tr>
<tr>
<td>3.1</td>
<td>scoreIncrease</td>
<td>✓</td>
<td>One-shot sound when player score increased</td>
</tr>
<tr>
<td>3.2</td>
<td>playerLevelUp</td>
<td>✓</td>
<td>One shot sound when player character increases in level</td>
</tr>
<tr>
<td>4.0</td>
<td>weaponFire1</td>
<td>✓</td>
<td>Weapon Fire for weapon X</td>
</tr>
<tr>
<td>5.0</td>
<td>horseTrot</td>
<td>✓</td>
<td>Horse trotting sound</td>
</tr>
<tr>
<td>5.1</td>
<td>horseNeigh</td>
<td>✓</td>
<td>Horse neighing sound</td>
</tr>
</tbody>
</table>

6.8.1.2 Adaptive design sound categorisation

For an adaptive design method, a similar approach is taken to predictive design. However, the table becomes a living record of sounds used in the game and, as the game is progressively developed and new game sounds added, the sound classification document is updated throughout the iterative design process. In addition, the game assessment framework can be repeated throughout the development process, ensuring that feedback is suitably accessible for the DHH as the game is developed, rather than conducting a single assessment on completion.
6.8.1.3 Review of accessibility in games sound categorisation

In addition to facilitating the development of accessible games for the DHH, the game assessment framework may be used for reviewing completed games. For example, assessments are often conducted by review websites and rated based on level of accessibility ("D.A.G.E.R. System," n.d.; "Gamecritics.com," n.d.; "Unstoppable Gamer," n.d.). The sound classification data could be provided by the developer, or manually recorded by the reviewer by playing through the game and making note of each individual sound heard throughout the course of a playtest.

6.8.2 Assessment stage

Once the sounds have been classified in the Categorisation stage, the documented sounds are then converted into an impact survey for the Assessment stage (Figure 101). Sounds are coded so they are easily identifiable. Multiple sound elements of the same type may also be combined for efficiency and readability, such as different sounds for weapon fire or walking on different surfaces (Figure 102).

Figure 101 Assessment Stage

Figure 102 Example grouping of similar sound elements
Table 26 Sound Impact Survey

<table>
<thead>
<tr>
<th>Game Sound Name</th>
<th>Minor</th>
<th>Moderate</th>
<th>Significant</th>
<th>Severe</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weapon Fire (ID 4.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking Sounds (ID 1.0 – 1.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Background Music (ID 2.0-2.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The impact survey (Table 26) is based on the ABC testing model (Feil & Scattergood, 2005), with testers providing one of the following ratings for sound elements:

- **Minor** sounds are the lowest priority, and are those which have little, if any, impact on the user experience and do not hinder the gameplay if removed;
- **Moderate** sounds have minimal impact on the gameplay, but may improve the player’s experience with additional visual feedback;
- **Significant** sounds are those which have an adverse impact on the difficulty and user experience if not heard; and
- **Severe** sounds are the highest priority, and can prevent the player from progressing and completing the game if unheard.

Using the sound impact survey, sound elements are classified by a play-tester, with the option of providing additional user feedback. Sound elements are evaluated based on the impact each sound, or group of sounds, has on the gameplay and the user experience. The evaluation considers existing visual feedback elements and the target demographic. For example, the impact of sounds for a game developed for children, which only utilises subtitles or closed captions in addition to audio, would likely result in different survey results than a game developed solely for an adult audience.
Two different approaches can be employed for testing the game sounds:

- **Free testing**, where the play-tester plays through the game as they would in their own time. Play-testers look for potential sounds that impede gameplay and user experience, and provide a rating for those sounds in the impact survey. This form of testing can potentially leave gaps, as not every sound may be tested (Feil & Scattergood, 2005).

- **Planned testing**, which is a rigid process and requires the play-tester to test each sound, based the impact survey which acts as a test plan. A test plan is a list of set tasks the play-tester must test within a given period (Feil & Scattergood, 2005). Test plans are often used in quality assurance testing, and are applicable in both predictive and adaptive approaches to game design. This form of testing does not consider emergence or account for issues that may arise outside of the documented testing process (Feil & Scattergood, 2005).

The approach to testing may include one or both methods, as the strengths of one method would complement the limitations of the other. Examples for the use of the Sound Impact Survey is provided in the following scenarios.

**Assessment stage Sound Impact Survey scenario 1**

A play-tester is free testing a 2D side-scrolling platform game for children with the sound disabled. While testing, the player’s character runs through what appears to be hot sand, and proceeds to jump down from a ledge. Shortly after, the play-tester realises his health has reduced in a health bar in the non-diegetic HUD (Figure 103). The tester is unsure whether the health loss was a result of walking on the hot sand, the fall, or another contributing factor.
When the play-tester plays through the same scenario again, this time with the sound enabled, he notices an audible one-shot ‘crack’ effect sound when he jumps off the ledge and hits the ground. The sound indicates the player’s character has received fall damage. The play-tester considers the fall damage effect sound to be a significant, and notes the impact of the sound in the impact survey (Table 27).

Table 27 Scenario 1 Survey Response

<table>
<thead>
<tr>
<th>Game Sound Name</th>
<th>Minor</th>
<th>Moderate</th>
<th>Significant</th>
<th>Severe</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Crack” when player falls</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>No visual indication of where the damage has come from, and I was unsure what had caused the damage. An additional visual indication would be beneficial.</td>
</tr>
</tbody>
</table>

Assessment stage Sound Impact Survey scenario 2

A play-tester is free testing a first-person perspective game, walking the player character through a forest. The forest is only safe to navigate during the day, as predators will attack the player as soon as it becomes night-time. Due to the tree canopy in the forest the play-tester is unable to see the sky to determine the time of day. In addition, the forest becomes dark very quickly, and does not leave the
player enough time to exit the forest. These factors contribute to the player’s character being attacked and subsequently dying. The play-tester repeats the process several times, and cannot determine when he is supposed to leave the forest, preventing him from progressing.

When the play-tester plays through the same scenario again, with the sound enabled, he notices the sounds of birds chirping and leaves rustling creating a peaceful ambience. However, as the day progresses, the ambient peaceful forest sounds slowly subside. The sound elements are steadily replaced with the sound of cicadas, accompanied by distant growls and screeches which become progressively louder as day turns to night. These sounds alert the player that it is time to leave the forest before it becomes dark or risk being attacked. The tester considers this a severe impact on the gameplay, and makes a note in the survey (Table 28).

Table 28 Scenario 2 Survey Response

<table>
<thead>
<tr>
<th>Game Sound Name</th>
<th>Minor</th>
<th>Moderate</th>
<th>Significant</th>
<th>Severe</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Sounds</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>Unable to tell when the player needs to leave the forest, as there are no other indicators other than the forest sound.</td>
</tr>
</tbody>
</table>

Assessment stage Sound Impact Survey scenario 3

A play-tester is conducting a planned test in a third-person adventure game. The player’s horse has run away and the player must follow the sounds of the horse galloping and neighing to find it. However, when the play-tester plays the game with no sound, he is unable to hear the horse. As a result, the player is unable to progress in the game. The tester notes that this is a severe impact on gameplay in the sound impact survey, and provides additional detailed feedback regarding the issue in the notes column (Table 29).
Table 29 Scenario 3 Survey Response

<table>
<thead>
<tr>
<th>Game Sound Name</th>
<th>Minor</th>
<th>Moderate</th>
<th>Significant</th>
<th>Severe</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horse Sounds</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>I was unable to find the horse at all without sound, and additional visual indicators are needed.</td>
</tr>
</tbody>
</table>

Table 30 is an example of a completed sound test survey based on these scenarios and sounds identified in example assets list (Table 25) for demonstration purposes. The survey includes grouped and coded sound elements, with each sound provided an impact rating based on an individual tester’s experience and observations. Additional feedback from users is provided in the notes column.

Table 30 Example Sound Impact Survey

<table>
<thead>
<tr>
<th>Game Sound Name</th>
<th>Minor</th>
<th>Moderate</th>
<th>Significant</th>
<th>Severe</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Player Footsteps (ID 1.0-1.1)</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weapon Fire (ID 4.0)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>There is no indication of enemy fire if you cannot hear the sound</td>
</tr>
<tr>
<td>Menu Sounds (ID 3.0)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Background Music (ID 2.0-2.1)</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horse Sounds (ID 5.0-5.1)</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>Unable to tell when to leave the forest.</td>
</tr>
<tr>
<td>Player Falling Sounds (ID 1.3)</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>No visual indication of where the damage has come from</td>
</tr>
<tr>
<td>HUD Sounds (score, level up) (ID 3.1-3.2)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest Sounds (ID 2.2-2.3)</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>Can’t tell when the forest become dangerous without sound.</td>
</tr>
</tbody>
</table>

Once testing has concluded, the results from surveys are collated, resulting in a list of the most critical sound effects found to impact gameplay and user experience. Based on these results, a developer can first address the most critical issues, which are those which significantly or severely impede gameplay and user experience, with the option of subsequently addressing less critical issues.
6.8.3 Implementation stage

The third stage (Figure 104) of the game feedback model involves implementation of visual feedback elements:

1. identification of each sound element in the assessment stage found to have an adverse impact on gameplay and user experience. Priority is given to those sounds which have been identified as having a severe or significant impact on gameplay;

2. determining the IEZA category of each problematic game sound identified, based on the sounds identified in the Categorisation stage;

3. cross-referencing the category for each problematic sound with the populated game feedback model (Table 21), to identify potential visual feedback elements to complement or substitute the audio feedback;

4. implementation of the visual VGUI element; and

5. re-assessing the sound(s) by repeating the Assessment stage.

This process is described in greater detail in the following implementation scenarios. Each scenario addresses the issues identified in the example scenarios in the Assessment stage.
Implementation Stage example scenario 1

During the second stage of the game assessment framework, an issue was identified in a 2D side-scrolling platform game for children. A health bar element, shown as a non-diegetic component in the visual user interface, depicted the player’s health loss. However, there was no explicit visual indication of what had caused damage to the player. In response, the tester noted in the sound impact survey that the ‘crack’ *effect* sound was a significant issue, and an additional visual indicator would be beneficial (Table 27). Using the sound categorisation table from the game’s production documentation in the Categorisation stage (Table 25), which lists the game’s sounds and categories, the problematic sound is identified as an *effect* sound. By referencing the game feedback model (Table 21) potential visual VGUI elements are identified to complement or substitute the audio feedback element. For example, the developer of the game may opt to use the existing non-diegetic HUD by adding dynamic elements, including:

1. textual explicit feedback stating how much damage was received, and the cause; and
2. an iconic sign to denote the area on the player that was injured, as a textual form of feedback may not be suitable for children with a limited reading ability (Figure 105).

![Figure 105 Character Fall Damage Detailed HUD Mock-up](Image)
Implementation Stage example scenario 2

In the second stage, a play-tester provided feedback regarding a severe impact on gameplay and user experience when free testing a first-person perspective game. The tester had identified that the ambient sounds in the game were used to indicate the time of day, which prompted the player to leave a forest to prevent being attacked. However, when the tester played through the game with no audio, they found the gameplay was severely impacted and they were unable to progress. The tester made note of this in the sound impact survey along additional feedback in the notes column (Table 28).

Based on the response, the previously recorded categorisation of sound elements from the first stage of the game assessment framework is used to identify the forest sound category (Table 30). The forest sounds are identified as a parent category for two different sounds, including day and night forest ambience. These sounds were classified as Zone sounds, which the developer uses to cross reference with the game feedback model (Table 21).

![Figure 106 First-Person Shooter HUD Mock-up](image)

While the developer could utilise a non-diegetic HUD element, such as a clock or icon to show the time of day, they feel that this will have an adverse impact the player’s immersion. Instead, the developer decides to implement a diegetic in-game device (Figure 106), which results in the
development of a watch on the player character’s arm to show the time of day. In addition, the developer includes further functionality to the watch, such as a compass to help direct the player, a heart rate monitor to indicate when the player is scared, and an alarm to indicate when it is time to leave, depicted by a red flashing light on the face of the watch.

**Implementation Stage example scenario 3**

In the second stage, a play-tester conducted a planned test in a third-person adventure game. During the testing, the play-tester identified that they were unable to complete an objective to find a horse without sound. This resulted in the game being unplayable, and severely impacted the gameplay and user’s experience. The tester made note of this in the sound impact survey, along with comments regarding the issue (Table 29).

The developer identifies the problem sound is a parent for three different horse sounds from the effect category (Table 30). This information was previously documented in the sound categorisation table developed in the first stage of the game assessment framework. Using the game feedback model as a reference (Table 21), the developer decides to trial several different approaches with play-testers, including:

- a spatial element with the silhouette of the horse (Figure 107);
- a non-diegetic directional marker (Figure 107);
- a geometric contextual icon, with textual overlay (Figure 108); and
- a spatial breadcrumb trail (Figure 108).
These scenarios have demonstrated how the refined model would function in a real world environment, and the comprehensiveness of the game assessment framework (Figure 99) in collaboration with the new visual feedback classification model (Figure 35), the new video game user interface representation (Figure 34), and the game feedback model (Table 21).

6.9 Third Iteration - Act

Cycle 3 of this research consisted of three iterations, involving exploration and investigation into the development of a potential solution to the research problem. The third iteration culminated in the development of a new game assessment framework to aid in assessment of the impact of game sounds and provide recommendations for complementary visual feedback elements. The framework was used to address three example scenarios, to demonstrate how the framework may be used. The findings of this cycle, in conjunction with the results of the literature review and the previous research cycles, aided in providing a response to the primary research question:

*Research Question 1: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?*
In response to the primary research question, accessible video game design practices for the DHH may be facilitated using a specially developed game assessment framework. The framework involves the following steps:

- A means of categorising specific sounds in a game, for both predictive and adaptive approaches to game design, using the IEZA Framework (Huiberts & van Tol, 2008);
- Assessing those sounds with user-feedback to determine the individual impact on gameplay and user experience, by using a method such as the new Sound Impact Survey (Table 26); and
- A method for identifying and implementing potential visual feedback elements using the amended visual feedback classification model (Figure 35), and cross-referencing the results with the new populated game feedback model (Table 21).

The framework is innovative and has the potential to provide practical guidance for developers of video games. In addition, this research provides the foundation for future research, with the potential to influence accessible game design for the DHH. This research has met the aims relating to the identification of approaches to game design and accessibility; understanding of audio-visual feedback elements; and the development of a potential solution to aid in developing accessible games for the DHH. Therefore, on conclusion of the third cycle, it was considered a suitable exit point for the research. The conclusions of this research are presented in Chapter 7.
Chapter 7: Conclusion

This chapter explains and reflects on the results of this research, identifies the contribution to scholarship, and describes the potential impact and future research. These topics are presented in the following sections:

- **Section 7.1** provides a summary of the research, the outcomes, and answers to the research questions;
- **Section 7.2** discusses how this research contributes to scholarship in the field of accessible video game design;
- **Section 7.3** identifies the significance and potential impact of this research; and
- **Section 7.4** presents potential future research and discusses how the new knowledge can be used.

### 7.1 Summary of research undertaken

The purpose of this doctoral research was to determine a means of facilitating accessible video game design for the deaf and hard of hearing (DHH). The research was driven by findings from previous research which highlighted issues with video game hearing accessibility. These issues related to accessible design choices, based upon existing industry guidelines and design frameworks, which were found to have an adverse impact on gameplay and user experience. Further investigation determined similar issues plague the video game industry, with minimal attention provided for inclusive design choices for the DHH. As existing approaches to accessible design were found to lack prescription, it was proposed an alternative approach to inclusive video game design for the DHH was required. Based on these findings the primary question for this research was formed:

*Research Question 1: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?*
Once the primary research question had been identified a critical analysis of literature was conducted. The literature review explored the breadth and severity of the research problem to define a scope and ascertain how the research question may be answered. The review identified several issues, including the lack of standardised definition for types of game software. The lack of classification and definition for serious games, simulations, virtual/micro worlds and purely entertainment games created a gap and had the potential to impede the progression of this research. Without a means of identifying the different types of game software, it was not possible to accurately identify the different approaches to game design. These findings led to the development of a new video game classification model (see Chapter 2.7.2). The new classification model addresses these issues, and presents:

- a new visual diagram, representing the spectrum of video game software (Figure 109); and
- individual definitions for types of game software, including identification of five core gameplay mechanics present in all purely entertainment games.

![New Video Game Spectrum](image)

**Figure 109 New Video Game Spectrum (adapted from (Qin et al., 2010))**

The new classification model informed a critical analysis of game design methods, including accessible game design. Preliminary investigation determined that there were various approaches to game design.
and accessible design, which required further investigation. These findings informed the first subsidiary research question:

**Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?**

In addition, it was initially intended to investigate all forms of feedback used in video games including audio, visual, haptic and tactile feedback, to determine which forms of feedback may be used to substitute or complement critical game sound. However, during the literature review it was discovered that haptic and tactile feedback required specific hardware which may not be supported by certain video game platforms (Table 4). Based on these findings, haptic and tactile feedback solutions were considered supplementary and a limitation of this research. The scope of the research was subsequently refined to visual and auditory forms of feedback.

Accessibility guidelines and previous studies were critically analysed, and found to frequently recommend the use of visual feedback elements as an alternative to game sound. However, these sources lacked specificity for identification of suitable visual elements and for technical implementation. As a result, it was determined that this research would focus on the identification and implementation of visual elements as a form of feedback to complement critical game sound and foster hearing accessibility. Based on the critical analysis of the literature, the following core areas were identified as necessary to answer the primary research question:

- determining the different approaches for designing video games and interrelationships;
- analysis of the different types of sound used in video games and the function of those sounds;
- identification and analysis of the different visual elements used in video games;
triangulation of the data collected, to determine how visual feedback elements may be used as an alternative to specific forms of game sound, to provide greater specificity than the current recommendations in accessibility guidelines and academic studies; and

determining whether the results could be formulated into a systematic approach to facilitate existing game design practices.

Through representation of the overarching research problem in a theoretical framework (Figure 11), and proposed solution in a conceptual framework (Figure 12), two subsidiary research questions emerged. These questions aided in further defining the primary research question:

*Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?*

*Sub Research Question 1.2: What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?*

![Figure 110 Look, Think and Act process for this research](image)

To address the research questions an action research method, based on the *Look, Think and Act* process (Stringer, 2014), was used. The method was a systematic approach, and consisted of three cycles to reflect the three research questions (Figure 110). The cycles were:
1. an analysis on current game design methods, to determine what approach would be best suited to facilitate the design of accessible games for the DHH;

2. an investigation into the different types and interrelationships of audio and visual feedback elements used in video games, to determine what visual elements may be used to complement game sound; and

3. the development of a potential solution to the research problem, based on findings from the first two cycles.

7.1.1 Sub-research question 1.1

Cycle 1 involved critical analysis of literature related to video game design methods and accessible video game design and interpretation of results. The aim of the cycle was to identify a practical solution to facilitate accessible design for the DHH, and response to the subsidiary research question:

*Sub Research Question 1.1: What are the different approaches used for the design of video games, and how might these be amended to facilitate accessible design for the deaf and hard of hearing?*

The results of Cycle 1 included thick, detailed descriptions and three independent diagrammatic representations of:

- the methods used for the design of video games and connections between methods (Figure 23);

- game design methods mapped to the different types of video game software, using the new video game classification model (Figure 109); and

- the interrelationships between the approaches to accessible game design and game design methods (Figure 111).
During interpretation of results, relating to the connections between accessible design approaches and game design methods (Figure 111), a solution to the primary research question emerged. Due to the various approaches to video game design it was determined neither guidelines or a new game design framework would suffice as a potential solution. Instead, it was decided that a game assessment framework would prove beneficial, because of its flexibility and application across methods of game design. Each of the new diagrammatic representations, and the identification of a potential solution, marked the end of the first cycle and addressed the first subsidiary research question.

7.1.2 Sub-research question 1.2

Cycle 2 of the research involved the analysis of different methods of classifying audio and visual elements used in video games. The aim of the cycle was to determine a means of identifying the visual
and auditory feedback elements used in video games, potential connections, and provide a response to the second subsidiary research question:

Sub Research Question 1.2: What visual elements may be utilised in design of video games, as an alternative to audio, to accommodate the deaf and hard of hearing?

By determining interrelationships between the two forms of feedback, the findings were used to provide recommendations for specific visual feedback elements to complement categories of game sound. Findings of the cycle determined that there was minimal prior research conducted into the classification of visual feedback elements in video games, except for a study related to the identification of visual elements in the first-person shooter genre of video games. To address this limitation, a new visual feedback classification model was developed for this research (Figure 112).

![Visual Feedback Classification Model](Based on Deshmukh, 2010; Fagerholt & Lorentzon, 2009; Russell, 2011; Stonehouse, 2014)

To aid in defining specific terms and concepts, and identifying where visual feedback elements appear in a video game user interface (UI), a new visual representation of the video game UI was developed (Figure 112). The generalisability addressed the potential issues identified in the original model, and is representative of the visual UI used various genres of video games.
The new visual feedback classification model was used in conjunction with the IEZA framework (Huiberts & van Tol, 2008), which is a model developed for the identification and classification of game sound types. Investigation identified numerous game sound classification methods including those based on the production process or on diegetic film theory. The IEZA framework was considered the most comprehensive, and subsequent analysis determined the most suitable for use with the new visual feedback classification model.

Table 31 Game Feedback Model

<table>
<thead>
<tr>
<th>Visual element (Identified via the new visual feedback classification model)</th>
<th>Game Audio Feedback Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Effect (Activity)</td>
</tr>
<tr>
<td>Non-Diegetic</td>
<td></td>
</tr>
<tr>
<td>Diegetic</td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td></td>
</tr>
<tr>
<td>Meta</td>
<td></td>
</tr>
</tbody>
</table>

By combining the two feedback classification models, the research presented a new game feedback model (Table 31). The model was used to analyse video games, through anecdotal observation, and was populated with data from findings. This data included the different forms of visual feedback.
elements, which were mapped to IEZA categories of game sound. Each visual feedback element was discussed with thick, detailed descriptions, and the analysis on several video games provided examples for implementation.

Table 32 Populated game feedback model

<table>
<thead>
<tr>
<th>UI Elements (Identified via Video Game UI Feedback Model)</th>
<th>Game Audio Feedback Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diegetic Sound</td>
</tr>
<tr>
<td></td>
<td>Effect (Activity)</td>
</tr>
<tr>
<td>Non-Diegetic</td>
<td></td>
</tr>
<tr>
<td>HUD</td>
<td>✓</td>
</tr>
<tr>
<td>Directional marker</td>
<td>✓</td>
</tr>
<tr>
<td>Subtitles</td>
<td>✓</td>
</tr>
<tr>
<td>Close Captioning</td>
<td>✓</td>
</tr>
<tr>
<td>Avatar Overlay</td>
<td>✓</td>
</tr>
<tr>
<td>Diegetic</td>
<td></td>
</tr>
<tr>
<td>HUD</td>
<td>✓</td>
</tr>
<tr>
<td>Signifiers and Subliminal Cues</td>
<td>✓</td>
</tr>
<tr>
<td>Lighting</td>
<td>✓</td>
</tr>
<tr>
<td>Particle Systems</td>
<td>✓</td>
</tr>
<tr>
<td>Avatar Signing</td>
<td>✓</td>
</tr>
<tr>
<td>In-game Devices</td>
<td>✓</td>
</tr>
<tr>
<td>Spatial</td>
<td></td>
</tr>
<tr>
<td>Geometric Indicator (icon, text etc.)</td>
<td>✓</td>
</tr>
<tr>
<td>Silhouette, Outline &amp; Highlighting</td>
<td>✓</td>
</tr>
<tr>
<td>Breadcrumb</td>
<td>✓</td>
</tr>
<tr>
<td>Meta</td>
<td></td>
</tr>
<tr>
<td>Screen Filter</td>
<td>✓</td>
</tr>
<tr>
<td>In-game devices</td>
<td>✓</td>
</tr>
<tr>
<td>Camera Manipulation</td>
<td>✓</td>
</tr>
</tbody>
</table>
As a core characteristic of action research is participation, Cycle 2 of the research also included a cross-sectional, self-administered survey. The purpose of the survey was to support findings of Cycle 2, through member-checking, and to determine the flexibility and comprehensiveness of the new game feedback model. Respondents provided textual feedback relating to alternative forms of feedback, to game sound, for the DHH. While most of the responses could be classified using the new game feedback model, one participant identified camera manipulation as a form of visual feedback that was unable to be classified. As a result, the game feedback model (Table 32), VGUI representation model (Figure 113), and visual feedback classification model (Figure 112) were amended to accommodate a camera manipulation visual feedback element category. The final populated game feedback model, and accompanying descriptive analysis of visual elements and connections to specific audio feedback categories, marked the end of the second cycle of the research and provided an answer to the second research question.

7.1.3 Primary Research Question

Cycle 3 of the research involved the triangulation of data from Cycle 1 and Cycle 2. The aim of the cycle was to determine how a systematic approach to guiding the accessible design of video games for the DHH might be developed. Results of the cycle were used to answer the primary research question:

Research Question 1: How might accessible video game design practices be facilitated to better accommodate the deaf and hard of hearing?

In accordance with the action research method characteristics of responsiveness and iteration, the cycle included three iterations to achieve the final game assessment framework (Figure 114). The first two iterations of the cycle identified issues relating to complexity, lack of flexibility and the
requirement for user-testing. The development culminated in a final game assessment framework, consisting of three stages:

- **Categorisation**, to identify, classify and code the different sounds used in a game, during or after development;
- **Assessment**, using participation from end-users, in the form of play-testing, to identify the impact of specific sounds on gameplay and user experience using a new Sound Impact Survey (Table 26); and
- **Implementation**, which involved selecting suitable alternative visual feedback elements using the populated game feedback model (Table 32) for categories of game sounds identified as having a severe impact on user experience and gameplay during the assessment stage.

Figure 114 Final game assessment framework

The framework was used to address several scenarios, as an example of implementation in both predictive and adaptive approaches to design, to inform future research. The findings of Cycle 3 determined that a game assessment framework might present a potential solution to guide the development of accessible games, using alternative forms of visual feedback, for the DHH. The completion of Cycle 3 was considered a suitable exit point for the research, as all aims of the research had been meet. The findings also answered the primary research question, which identified a game assessment framework as a potential solution to facilitate the accessible design of video games for the DHH, using visual feedback elements to complement or substitute critical game sounds.
7.2 Contribution to scholarship

This section describes the original contribution to scholarship this research provides. The discussion has been presented based upon the four principle deliverables of the research:

- **Section 7.2.1** describes the new video game classification model, and original contribution to academic research and education;

- **Section 7.2.2** describes the new representation of game design methods, including approaches to accessible design, and original contribution to academic research;

- **Section 7.2.3** discusses the new visual and auditory feedback classification methods, and the original contribution to academic research; and

- **Section 7.2.4** discusses the game assessment framework, and the potential implications for future academic research and education.

7.2.1 Video game classification

The first original contribution of this research to scholarship is the understanding of classification for serious games, simulations, virtual worlds, and entertainment games. As identified in Chapter 2 Literature Review, there are various definitions for what constitutes a serious game, with some believing the term ‘serious game’ refers solely to educational video games. However, based on an analysis of forms of serious games, it was evident that the serious games domain extends beyond education. Serious games were found to encompass numerous areas such as health, education, and scientific exploration.

The new model includes individual definitions of simulations, serious games, virtual/micro worlds and games for purely entertainment purposes (Figure 4). New concepts of purposeful and adapted approaches to serious games development were identified to account for previously unclassifiable
forms of serious games. In addition, the revised classification introduced game mechanics (Table 1), which are video game characteristics used to identify and distinguish video games from other forms of computer software.

While the new model and classifications were intended to be used solely for this research, to identify the different game design methods, the potential implications extend beyond this research. It is expected others could derive similar conclusions based on the findings in the literature review. The new classification may contribute to finally achieving a universally recognised definition of terms. In turn, this has potential implications in academia, for future research, and for the education of both novice and expert game designers.

7.2.2 Identification and classification of game design methods

An additional contribution to scholarship stems from findings and framing of the current state of the video game industry in relation to game design and development practices, which extends understanding of video game design methods and approaches to accessible video game design. During Cycle 1 of this research the methods for game design were identified, and presented in a new visual representation (Figure 23). Findings provided evidence for the claim that the video game industry employs two vastly different approaches to design, including predictive and adaptive practices, which were concepts first explored by Hunt (2011).

This research extends on Hunt’s (2011) concept significantly, providing a detailed analysis and visual representation of game design methods. The representation also introduces concepts of targeted and generalisable approaches to design. Further, the different approaches to accessible design and interrelationships with each game design method were identified. This is significant, especially for
research related to accessibility and game design methods, where it is important to highlight the fact that a systematic approach to the design and development of video games is not the sole industry standard. This concept should be recognised in future research related to video game accessibility and game design.

7.2.3 Visual and auditory feedback classification

The new visual feedback classification model (Figure 112) and VGUI representation (Figure 113) provide a means of classifying visual elements in all video game genres. This is significant, as it contributes new theory and understanding of forms of visual feedback, game sound and interrelationships. Further, this provides a foundation for future research involving visual elements of a VGUI, including other areas of accessible game design such as visual impairment (see 7.4 Future Research). The identification of a means of classifying specific categories of visual elements may also aid in the amendment of accessibility guidelines, fostering consistent and prescriptive guidance.

7.2.4 Game assessment framework for hearing accessibility in video games

In addition to classification of visual feedback elements, this research contributes new theory with the development of a new game assessment framework for systematic assessment and implementation of hearing accessibility solutions in video games. The framework provides a means of identifying which visual elements may be used to complement critical game sounds. This was provided through the development of a game assessment framework (Figure 114). The framework and accompanying elements, such as the game feedback model (Table 32) and Sound Impact Survey (Table 26), permits:

- the identification and classification of sounds used in a video game;
- the impact the sound has on a DHH audience’s gameplay and user experience; and
- identification of visual elements to complement game sounds critical to gameplay.
This is an original contribution with significant implications for academic research and for education, as there were previously no other means of conducting such an assessment. For example, the game assessment framework may be used to revisit previous research which informed this research. The previous research involved the development of a serious game for screening and diagnosis of hearing loss in children, and was impeded by unsuitable design choices for DHH children. Using the game assessment framework could lead to increased accessibility and user engagement, resulting in improved accuracy and reliability of the test. This, in turn, could result in increased diagnosis of hearing loss and middle ear disease in children, and lead to early intervention sooner.

In addition, there is potential application of the game assessment framework for providing instruction to novice designers and students of game design. As previously identified, novice designers, and those unfamiliar with game development, often require additional guidance during the design process (McMahon, 2009). Students often cite difficulties with accessible design during game design assessments, due to lack of specificity with existing published resources. The game assessment framework may provide students with the additional guidance required, enabling students to achieve suitably accessible design for the DHH.

### 7.3 Impact of this research

The main discipline that this research has aimed at contributing to is the field of accessible video game design practice and research. However, the potential impact extends to other domains such as the DHH community and the video game design industry at large. This section discusses the potential impact, and is presented in the following sections:

- **Section 7.3.1** Impact for community; and
- **Section 7.3.2** Impact for industry
7.3.1 Impact for community

The potential implications of this research include extending understanding of needs of DHH gamers. For the DHH community and accessible video game design industry this is significant. As identified in the literature review, the consensus toward hearing accessibility in video games was DHH users are those who encounter the least barriers and are generally well catered for by existing accessibility approaches (Media Access Australia, 2014; Torrente et al., 2014). This research challenges those claims by identifying and exploring issues with existing hearing accessibility solutions for video game design, and brings attention to the need for change.

As discussed throughout this thesis, a common approach for hearing accessibility has been found to primarily rely on textual feedback such as subtitles and captions. However, findings of this research determined subtitles and captions lack a universal definition and standard. This has historically resulted in an inconsistent and often inefficient approach to design and implementation. The potential implications of these findings may lead to appropriately designed captions and subtitles in video games, resulting in greater accessibility for the DHH.

In addition, subtitles and captions were deemed unsuitable for specific target audiences such as children. In turn, this research recognised the importance of alternative visual feedback elements as a potential solution to facilitate hearing accessibility. Similar recommendations were made in both accessibility guidelines and academic studies, which referred to the use of visual forms of feedback to complement critical in-game audio. However, subsequent investigation identified the lack of resources, academic or otherwise, for identifying and classifying the different forms of visual feedback in video games.
Implications for this research derive from those findings, where a means of identifying and classifying the different forms of visual feedback in video games were developed in the form of a new visual feedback classification model (Figure 35) and new VGUI representation (Figure 34). By providing a means of identifying and implementing alternative forms of visual feedback to accompany critical game sound, this research has the potential to influence a state of change and increase hearing accessibility for DHH who are unable to benefit from textual feedback.

7.3.2 Impact for industry

In relation to industry, benefits include a potential reduction in cost and development time for the design of accessible games which cater for the DHH. For example, previous alternative solutions for hearing accessibility have historically focused on the use of specific hardware platforms, such as virtual reality, which requires fixed, costly, and/or cumbersome hardware (Adamo-Villani & Wright, 2007; Eden & Passig, 2000). The ability to design accessible games, for the DHH, without a reliance on specific hardware, may facilitate the development of accessible games for common consumer devices. This could potentially reduce expenditure of equipment for end users, while increasing ease of distribution and decreasing development cost and time for developers. Further industry benefits include (Moss, 2014; Powers et al., 2015; Zahand, n.d.):

- the provision for game developers to design their games for an already interested demographic;
- increased media attention, by leading the accessibility movement;
- increased creativity for designers;
- benefitting the abled gaming population, by providing additional options to improve user experience; and
- may potentially result in increased revenue for those developers.
Finally, it is important to note the potential impact this research may have in relation to the industry approaches to guiding accessible design. In the final weeks before this thesis was submitted for examination, ideas for the development of a centralised web-based accessibility feedback tool were presented by the Game Accessibility Special Interest Group (GASIG) Roundtable at the 2017 Game Developers Conference ("GDC 2017 Roundtable Notes," 2017). Subsequent discussion has continued through the International Game Developers Association GASIG mailing list (Hamilton, 2017). This research has direct applicability to the research and development of such as tool, and has the potential to inform and influence development relating to hearing accessibility.

7.4 Future research

This thesis presented a new game assessment framework as a potential solution for facilitating the development of accessible video games for the DHH. While the framework was not used in field-based evaluation, the research informing its development was detailed, comprehensive, and provides the foundation for future research. This section discusses the areas of future research in the following sections:

- **Section 7.4.1** evaluation of the new game assessment framework;
- **Section 7.4.2** revisiting previous research in video games impacted by hearing accessibility issues;
- **Section 7.4.3** continued evaluation of the game feedback model; and
- **Section 7.4.3** investigation into the application of the game feedback model and game assessment framework in other domains of accessibility.
7.4.1 Evaluation of the game assessment framework

The game assessment framework presented in Chapter 3 was developed as a proposed solution to the research problem. Despite this research ceasing after the third cycle, the framework was not evaluated in a real-world scenario. This was due to use of the framework in the field being beyond the scope of this research. Research into the efficiency of the game assessment framework in real-world applications would further extend the practical value of the accessibility solution.

7.4.2 Revisiting Previous Research

Previous academic research informed this research by bringing attention to the issues related to accessible design for the DHH. The previous research investigated the potential of a serious game to be developed to aid in the screening and diagnosis of hearing loss in children. However, results of the study determined that design choices impeded the effectiveness of the serious game. It is proposed that a follow-up study may be conducted to revisit the original research problem. In addition, the results of future research may be used for evaluation of the game assessment framework.

The intention is to use the game assessment framework to develop a new serious game to address the research problem identified in the previous research. This would involve the development of a serious game to aid in the screening and diagnosis of hearing loss in children, and subsequent testing to determine the accuracy and feasibility in comparison to a gold standard hearing test. The development of the serious game would use the same DODDEL model to guide design. However, the game assessment framework would be integrated during the production documentation stage of design.

The research would involve collecting data related to users’ experience and gameplay to evaluate the design aspects of the game. Results would be compared to results from the previous study to
determine whether the game assessment framework aided in developing a suitably accessible game for the DHH. Successful development of an accessible serious game would serve as proof of concept for the game assessment framework, and substantiate the possibility for wider acceptance.

7.4.2 Extension of the game feedback model

Cycle 3 of this research involved the development of a game feedback model (Table 32). The model was used to facilitate the identification and classification of visual UI elements in a video game. Several video games were analysed using the model, and the game feedback model was populated with data from the analysis. However, it has been previously established that the video game industry experiences constant and rapid growth. This is due to technological advancement in both hardware and software capabilities. Additional study and evaluation of the game feedback model would ensure the continued relevance and further extend its value as a tool for identification of visual feedback elements in the future.

7.4.3 Visual Accessibility

It is hypothesised that the game assessment framework (Figure 114) may be used to guide the development of accessible video games for the visually impaired, such as those with low level vision. The current structure of the game assessment framework first requires the categorisation of game sounds and assessment on the impact of those sounds on user experience and gameplay. Based on results, suitable complementary visual feedback elements are selected from the game feedback model (Table 32). Conceivably, altering the process would result in a viable means of guiding the development of accessible games for the visually impaired. However, further research and user testing would be required to verify the hypothesis. The adapted process for future research is proposed as follows (Figure 115):
1 **Categorisation stage**

Visual forms of feedback would be identified and documented during the development of a game. Each visual element would be classified using the existing game assessment framework (Figure 114) as a reference.

2 **Assessment stage**

Visual elements would be formatted, or coded, in an Impact Survey. Following the same assessment and user-testing process documented for the assessment of game sounds, visual elements would be provided a rating based on the impact on the user’s experience and gameplay.

3 **Implementation stage**

By collating the results of the impact surveys, developers could identify the visual elements with the highest level of impact. Using the categorisation of visual elements in the first stage, and the game feedback model, the developer could identify alternative audio feedback categories to complement the visual forms of feedback.

This research has, through investigation, identified limitations in existing approaches to accessible video game design for the deaf and hard of hearing. Further, the research has demonstrated how a new game assessment framework may be used to address these limitations. The framework is innovative and provides relevant and practical guidance for the application of hearing accessibility solutions in both predictive and adaptive video game design methods. The game assessment

Figure 115 Game assessment framework for visual impairment
framework also provides a foundation for future research aimed at improving excellence in inclusive video game design.
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Appendices

Appendix A: Information sheet- Subtitle and closed captions survey

Informed Letter to Participants

A Sound Idea: An Investigation into a New Serious Games
Developmental Design Framework for Children with a
Hearing Loss

Researchers and Contact details:
This research project is being undertaken as part of the requirement of a PhD at
Edith Cowan University. Details of the research team are as follows:

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Description of the research project

Background
Hearing loss in children, particularly those in rural and remote areas, is a growing health concern and is known to have an adverse impact on educational and social development is left undiagnosed, or without early intervention.

Fortunately, recent advancement in technology have prompted the use of both computer hardware and software to aid in the diagnosis and management of health conditions, as well as other applications such as education. These solutions may include specially developed video games, often referred to as ‘edutainment’, ‘elearning’, or ‘serious games’.

However, a recent investigation has determined that, while these games have proven beneficial, there is currently limited data regarding the implementation for children who are deaf of hard of hearing. This is a serious concern, not only for the end users, but also for the developers of video games.

As a result, the FCC has imposed regulations for all video games to conform to the Communications and Video Accessibility Act (CVAA) by 2015. However, without additional research into the area of addressing accessibility needs for children who are deaf or hard of hearing, both novice and expert developers may continue to develop games that do not adhere to the new regulations.

As a potential solution, this research project is being conducted to aid in the development of a new design framework and guidelines for the development of accessible serious games for children who are deaf or hard of hearing.

Aims
The study aims to:
1. Provide a detailed analysis of existing serious games, current industry guidelines for game design and accessibility, developmental and instructional design models, and develop an understanding of suitable game-play mechanisms for children who are deaf or hard of hearing.
2. Develop a developmental design framework and guidelines, in collaboration with industry experts and academics, to aid in design of accessible serious games for children with a hearing loss.
3. Test the new developmental design framework and guidelines with novice designers, to determine the usability and comprehension.
Project Stages
The study involved four stages, or ‘cycles’, including:
1. Development of the new design framework and guidelines, based upon an extensive literature review or current guidelines, academic papers, and industry recommendations.
2. Use of the new framework and guidelines in the design of a design document, and prototype serious games, to identify potential gaps or issues, with consultation with a reference group.
3. A focus group, to provide feedback on the new framework and guidelines.
4. Use of framework and guidelines by student designers, with evaluation in comparison to existing developmental models.

Selection of Participants
To ensure the new framework and guidelines meet requirements, the research involves collaboration and participation from various experts, throughout the life of the study.

You have been selected as a potential participant for the second cycle, as part of a reference group of experts, due to your knowledge and experience in the areas of game design, UX (user experience design), education, and/or child development.

Expectations
As a participant of the reference group, it is expected that you will participate in at least one individual interview session between [Start Date] and [End Date]. The interview will be face-to-face, and is not expected to exceed 1 hour.

Participants are encouraged to choose a location for the interview, which provides minimal inconvenience for travel arrangements. The location should be somewhere you feel comfortable, and free from disruption. However, if you are unable to suggest a location, the interviewer may suggest a location to meet.

During the interview, you may be presented with materials from the study, and asked to provide advice or feedback. Unlike a traditional interview, interview questions will not be structured, and the interviewer may generate questions during the interview. As a result, a copy of the interview questions may not be provided prior to the interview. However, a copy of sample questions may be provided upon request.
**Potential discomfort or inconvenience**

The interviewer will generate questions throughout the interview, in relation to the content discussed. As a result, it is important to note that you are not required to answer any questions which elicit discomfort. During the interview you may decline to answer any question, or terminate the interview at any time.

(Please see *Withdrawing Consent to Participate* for additional information.)

There are no other foreseeable issues that may result in discomfort or inconvenience.

**Potential Risks**

There are no foreseeable risks associated.

**Potential Benefits**

The main benefits associated with the study include shared knowledge, and the potential to guide the development of accessible serious games for children who are deaf or hard of hearing in accordance to FCC regulations.

Current research shows the benefits of serious games include safe and cost effective mechanisms for training; increased and maintained attention; accommodation for multiple learning styles; the ability to teach and expand upon concepts; and increased retention of knowledge.

The ability to extend these benefits, to children who are deaf or hard of hearing, may also result in future serious games aiding in telehealth solutions, such as diagnosis and early intervention, and educational applications.

**Confidentiality of Information**

The audio recorded during the interview will be transcribed, and used for data analysis, to aid in the revision or refinement of the design framework and guidelines. Responses to interview questions may also be used in the final documentation for the research.

The information will remain anonymous, and no names or information about you will be released. To maintain confidentiality, pseudonyms will be used to refer to each participant, rather than using given names, as a reference point for the research. This is in accordance to legal rights and limits to confidentiality.
The data gathered will be stored as follows:

- Audio from the interview will be recorded using an Apple iPod, protected with passcode access. On completion of the interview, the audio data will be transferred, stored and encrypted on a computer and erased from the Apple device.
- The audio recording will be transcribed to a digital word processing document, and coded using a pseudonym.

Results of the research study

Results of the study will be used to develop a final report, and may be used for further publications such as conference papers or future publications. Results will not include any information that may identify individual participants.

Further information about the study or the results of the study can be provided upon completion on request.

Voluntary Participation

Choosing to participate
If you would like to participate, please complete the attached Informed Consent Document, and return to the researcher prior to the commencement of the interview.

Choosing not to participate
Participation in the research study is completely voluntary, and no explanation or justification is required if you choose not to participate.

Withdrawing consent to participate
You are free to withdraw your consent to be interviewed at any time during the second cycle. Please note that once data has been collected at the end of the second cycle, the material may not be withdrawn.

Questions and/or further information
If you have any questions or require any further information about the research project, please contact:

Luke Brook
Phone: 0401 904 671
Email: bbrook0@our.ecu.edu.au
**Independent contact person**

If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

Research Ethics Officer  
Edith Cowan University  
270 Joondalup Drive  
JOONDALUP WA 6027  
Phone: (08) 6304 2170  
Email: research.ethics@ecu.edu.au

**Approval by the Human Research Ethics Committee**

This research project has been approved by the ECU Human Research Ethics Committee, in accordance to guidelines contained in legislation and policies, to ensure that research participants are accorded the respect and protection that is due to them, the protection of privacy, and will continue to effectively monitor the approved research project.
Appendix B: Informed consent document- Subtitle and closed Captions survey

Informed Consent Document

A Sound Idea: An Investigation into a New Serious Games Developmental Design Framework for Children with a Hearing Loss

Researchers and Contact details:
This research project is being undertaken as part of the requirement of a PhD at Edith Cowan University. Details of the research team are as follows.

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Consent to participate:

I have been asked to give consent to participate in this research study, which is aimed at developing a framework and guidelines for the development of accessible serious games, for children who are deaf or hard of hearing.

1. My participation in this project is voluntary. I understand that I will not receive remuneration for participation. I may decline to participate, withdraw or discontinue from participating at any time without explanation or penalty. If I withdraw after the testing phase is complete, any data collected cannot be withdrawn, as it is anonymously collected and individual results non-identifiable.

2. I have been provided with a copy of the Informed Letter to Participants, explaining the research study. I have read the Informed Letter to Participants, or it has been read to me, and I have understood the information provided.

3. I understand that participation involves being interviewed, on at least one occasion, during the second stage of the research. The interview is not expected to exceed 1 hour.

4. I have had the opportunity to ask questions about the research study, and any questions that I have asked have been answered to my satisfaction. I may contact the research team if I have any additional questions.

5. I understand that the researcher will not identify me by name in any reports using information obtained from this study, and that my confidentiality as a participant in this study will remain secure. Subsequent use of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions.

6. I understand the information provided will be kept confidential, my identity will not be disclosed without consent, and the information provided will only be used for the purpose of this research project.

7. I understand that this research study has been reviewed and approved by the Human Research Ethics Committee at Edith Cowan University. For research problems or questions regarding the study, I can contact an independent person on:

   Research Ethics Officer  
   Edith Cowan University  
   270 Joondalup Drive  
   JOONDALUP WA 6027  
   Phone: (08) 6304 2170  
   Email: research.ethics@ecu.edu.au

I freely consent to voluntarily participate as a participant in this study.

Printed Name ____________________________ Date ______________

Signature ________________________________
Appendix C: Survey question design

The survey was designed as a cross-sectional self-administered survey to gather both qualitative and quantitative data. The survey was developed and managed using the Qualtrics survey software, provided by Edith Cowan University for research students ("Qualtrics," n.d.). The selection of Qualtrics was due to the inbuilt functionality of the software to aid in the design of surveys, distribution, and data collection and analysis by generating real-time reports.

The survey comprised of twenty questions, including seven multiple-choice questions relating to participant’s consent, age group, gender, country, and whether the participant had been employed in the video game industry. The remaining thirteen questions asked participants about:

- video gaming preferences;
- comprehension of subtitles and captions in games;
- reasons for/against use; and
- awareness of additional forms of hearing accessibility.

Of those thirteen questions, the following formats were used:

- Nine multiple choice questions to collect quantitative data;
- Three five-point Likert scale questions to collect quantitative data; and
- One open-ended question, requiring a textual response, to collect qualitative data.

The first three questions in the survey were accompanied by a letter of consent, and required the participant to indicate who would be completing the survey:

- Please indicate who you are providing consent for:
  - Myself
  - A child for who I am the parent/ guardian
This question was based on conditional logic, and one of two questions would then be displayed. If the participant answered ‘Myself’ to question 1, then question 2 was then displayed:

- *I am 18 years or older, and freely consent to voluntarily participate in this study*
  - Yes
  - No

If the participant answered, ‘a child for who I am the parent/guardian’, to question 1, then question 3 would be displayed:

- *I give consent for my child to voluntarily participate in this study.*
  - Yes
  - No

The purpose of questions 1-3 was to ensure permission was provided to use participant responses for this study. Participants were unable to proceed with the survey if they selected the ‘no’ checkbox. Once a participant provided consent, they were permitted to continue, and the subsequent four questions were:

- *Gender*
  - Male
  - Female
  - Other
  - Prefer not to say
- *What age group are you in?*
  - 0-4 years, 5-4 years, 15-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75 years and above
- *Country*
  - Dropdown box of predefined countries provided by the Qualtrics software
- *Have you ever been employed in the video game industry?*
The purpose of questions 4-8 was to determine who was responding to the survey. This included whether participants who experienced hearing loss had differing opinions of subtitles and closed captioning; and whether participant responses differed between those who had and had not been employed in the video game industry.

Questions 8 and 9 were:

- How often do you play video games?
  - Every day
  - 2-3 times a week
  - Once a week
  - 2-3 times a month
  - Once a month
  - Less than once a month

- How often do you play video games on the following platforms?
  - Mobile games
  - Home consoles
  - PC Games
  - Handheld consoles

These questions used a five-point Likert scale, with options including Never, Not Often, Sometimes, Often, All the Time. The purpose of questions 8-9 was to determine whether participants, with a preference for a specific gaming platform, had differing opinions on hearing accessibility and the use of subtitles and captions on those platforms.

Question 10 was related to comprehension of subtitles and captions:
Video games often have options to display audio as on-screen text. These are generally referred to as subtitles and/or closed captions. Are you aware of any differences between subtitles and closed captions?

- Yes
- No

The purpose of question 10 was to determine whether participants were aware of the differences between subtitles and closed captions. Following this question, an information box was displayed advising the participants of the lack of standards and the distinction between subtitles and closed captions in specific countries (Figure 116).

The inclusion of this information was to assist participants in answering the subsequent two questions. Questions 11, 12 and 13 related to the participant’s use of subtitles and closed captions in games, and were based on conditional logic.
• Do you use subtitles in the games you play?
  ▪ Yes, I always make sure subtitles are turned on.
  ▪ I only leave subtitles on if they are enabled by default, but otherwise won’t turn them on.
  ▪ No, I never use subtitles

If the participant responded with ‘yes’ or ‘I only leave subtitles on if they are enabled by default’ to question 11, then question 12 would be displayed. This question allowed the participant to select multiple responses including an ‘other’ field to facilitate a textual response if the predefined answers were insufficient.

• What are your reasons for enabling subtitles?
  ▪ I have a hearing loss
  ▪ English is a second language
  ▪ They help me understand character speech
  ▪ They help me understand the story
  ▪ I sometimes have difficulty with characters’ accents
  ▪ I don’t want to miss any crucial information
  ▪ They help me understand when characters speak too quickly
  ▪ They help me understand how to play the game (in-game cues, instructions etc.)
  ▪ I often play in a sound sensitive environment, and need to keep the audio low so as not to disturb others.
  ▪ I find that music and/or sound effects can overpower pivotal dialogue
  ▪ Other (describe)

If the participant responded with ‘no’ to question 11, question 13 would instead be displayed. The question permitted the selection of multiple responses, including an ‘other’ field for a textual response.

• What are your reasons for not enabling subtitles?
  ▪ I’ve never used them
  ▪ Subtitles aren’t available in the games I play
• The games I play don’t rely on, or use, meaningful dialogue
• They distract me when I’m playing the game
• I find them difficult to read
• I’m too busy playing the game to read
• Other

Question 14 followed the same format as question 11. This required the participant to answer a question regarding their use of captions.

• Do you use closed captions in video games?
  • Yes, I always make sure captions are turned on
  • I only leave closed captions on if they are enabled by default, but otherwise won’t turn them on.
  • No, I never use closed captions

Using conditional logic, one of two questions would then be displayed. If the participant responded with ‘yes’, or ‘I only leave closed captions on if enabled by default’, question 15 would be displayed. The question allowed the participant to select multiple responses, with an ‘other’ field providing a text field for additional information.

• What are your reasons for enabling closed captions?
  • I have a hearing loss
  • English is a second language
  • To help me understand character speech
  • To help me understand the story
  • I sometimes have difficulty understanding characters’ accents
  • I don’t want to miss any crucial information
  • They help me to understand when characters speak too quickly
  • They help me understand how to play the game (in-game cues, instructions etc.)
I often play in a sound sensitive environment, and need to keep the audio low so as not to disturb others.

- I find that music and/or sound effects can overpower pivotal dialogue
- Other (describe)

If the participant responded with ‘no’ to question 14, then question 16 would instead be displayed. The question allowed for the selection of multiple responses, including an ‘other’ field for a textual response.

- What are your reasons for not using closed captions?
  - I’ve never used them
  - Closed captions aren’t available in the game I play
  - The games I play don’t rely on, or use, meaningful dialogue
  - They distract me when I’m playing the game
  - I find them difficult to read
  - I’m too busy playing the game to read
  - Other

Question 17 and 18 were formatted as a five-point Likert scale, for gauging participants’ experiences and opinions of subtitles and closed captions in the games they play. For question 17 participants had the option of selecting one of five fields, including Never, Rarely, Sometimes, Often, All the Time.

- Please answer the following about your experiences with subtitles and closed captions:
  - Subtitles are available in the games I play
  - Closed captions are available in the games I play
  - Subtitles help me to play games
  - Closed captions help to me to play games
  - I find games more enjoyable with subtitles
  - I find games more enjoyable with closed captions
For question 18, the available responses included Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree.

- Please answer the following about your opinions of subtitles and closed captions:
  - I prefer subtitles to closed captioning
  - More games need to use subtitles or closed captions
  - There needs to be a standard to define closed captioning and subtitles in video games
  - Closed captioning should be mandatory in video games
  - Subtitles should be mandatory in video games
  - I would like to see different ways of conveying audio in video games

Question 19 and 20 were formatted as multiple-choice questions, with ‘yes’ or ‘no’ options. If the participants selected ‘yes’, they were required to provide additional information via a text input field.

- Do you know of any other in-game options that provide audio information in another way?
  - Yes (describe)
  - No

The purpose of question 19 was to determine whether participants were aware of additional options in video games, used to provide information that is typically provided via game audio. This question was open ended, to allow participants to describe alternative forms of feedback in their own words. It was intended that results from this question would be cross-referenced with the results of the second iteration of Cycle 2.

Finally, question 20 permitted the participants to provide any additional comments regarding the survey. The purpose of this question was to offer the participant the option to provide with any additional comments or feedback regarding the survey, or topics related to the survey.
Do you have any other comments or questions?

- Yes (describe)
- No

If in question 20, ‘Yes’ was selection, then a free text comment box was presented.
Appendix D: Subtitles Survey

Default Question Book

Letter of Consent

Dear Participant,

You are invited to participate in a research project by completing this short, anonymous survey. The purpose of this project is to identify your views and opinions of subtitles and closed captions in video games. This research is an essential component in the development of new game accessibility guidelines, to aid developers in creating games suitable for people who are deaf or hard of hearing.

This survey will take approximately 10 minutes to complete and is completely optional. If you are a student of Edith Cowen University, your participation in the survey will have no effect on your results or unit outcomes. You may opt to withdraw your participation in the survey at any time.

If you are under 18 years of age, and you wish to participate, a parent or guardian is required to consent on your behalf.

If you agree to participate, please consent by clicking the link below and completing the survey at a time convenient to you. Your participation in the survey is completely anonymous, and no personally identifiable information is collected at any point in time.

If you have any questions or concerns, require additional information, or have a complaint about the research project, please do not hesitate to contact me or the Edith Cowen University Research Ethics Officer listed below.

For additional information about the research, and your participation, please download the Informed Letter to Participants below.

Luke Broek

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Independent Contact Person
If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

Research Ethics Officer
Edith Cowen University
270 Joondalup Drive
JOONDALUP WA 6027
Phone: (61) 8 6204 2170
Email: research.ethics@ecu.edu.au

Approval by the Human Research Ethics Committee

This research project has been approved by the ECU Human Research Ethics Committee. In accordance to guidelines contained in legislation and policies, to ensure that research participants are accorded the respect and protection that is due to them, the protection of privacy, and will continue to effectively monitor the approved research project.

Please indicate who you are providing consent for
- Me
- A child for whom I am a parent/guardian
I gave consent for my child to voluntarily participate in this study
- Yes
- No

I am 18 years or older, and freely consent to voluntarily participate in this study
- Yes
- No

Gender:
- Male
- Female
- Other
- Prefer not to answer

What age group are you in?
- 0-4 years
- 5-14 years
- 15-24 years
- 25-44 years
- 45-64 years
- 65-74 years
- 75 years and above

In which country do you reside?

Have you ever been employed in the video game industry?
- Yes
- No

How often do you play video games?
- Every day
- 3-4 Times a Week
- Once a Week
- 3-5 Times a Month
- Once a Month
- Less than Once a Month

How often do you play video games on the following platforms:

<table>
<thead>
<tr>
<th>Platform</th>
<th>Never</th>
<th>Not often</th>
<th>Sometimes</th>
<th>Often</th>
<th>All the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Games (Smartphone, Tablet Devices such as iPad or iPhone)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Home consoles (Xbox 360, Xbox One, PlayStation 4, Wii, Wii U, Steam)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>PC Games (Windows/Linux/Ubuntu)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Handheld Consoles (Nintendo DS/3DS, PlayStation Vita, Sony PSP)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Video games often have options to display audio as on-screen text. These are generally referred to as Subtitles and Closed Captioning. Are you aware of the differences between Subtitles and Closed Captioning?
- Yes
- No

About Subtitles and Closed Captioning:
The terms subtitles and closed captioning are often used interchangeably, depending on locale. For example, in European countries, such as the UK and Ireland, there is no significant distinction. However, in Australia, the United States, and Canada, the technical specifications differ greatly.

For the purposes of this study, the terms are based upon the Australian Broadcasting Services Act 1992 (the BSA). Detailed descriptions for both Subtitles and Closed Captioning will be provided at the beginning of each question relating to these terms.
Subtitles:
The term subtitles refers to text which is displayed on-screen, to describe character speech in video games. Descriptions vary, depending on the developer of the video game, and may include additional information, such as the name of the character or different colors to denote different speakers. Subtitles are also used as a form of language translation.

For TV and movies, there are specific regulations for subtitles, including the size of the text, and positioning of the text on the screen.

Closed Captions:
Closed captions differ from subtitles, and are used to represent all meaningful sound in a video game, including character speech, and sound effects. As video games often use sound to convey actions or events, closed captioning provides descriptive on-screen text to explain these important inclusions, which may otherwise be lost. Non-speech events are often encoded in square brackets, and different colors, or bold and italic text are often used to differentiate events from speech.

The following questions are related to subtitles in video games.
The term subtitles refers to text which is displayed on-screen, to describe character speech in video games.

Figure 1 demonstrates the use of subtitles in Tomb Raider, with character speech displayed as white text on a black background.

Do you use subtitles in the games you play?
- Yes, I always have the subtitles turned on.
- I only use subtitles when they are enabled by default, but otherwise I turn them off.
- No, I never use subtitles.

What are your reasons for enabling subtitles?
(You can select multiple options)
- I have a hearing loss
- English is a second language
- They help me understand character speech
- They help me understand the story
- Sometimes I have difficulty with character's accents
- I want to miss any crucial information
- Other

What are your reasons for not enabling subtitles?
(You can select multiple options)
- I have never used them
- The games I play don’t rely on, or use, meaningful dialogue
- They distract me when I’m playing the game.
- I find them difficult to read.
- Other

The following questions are related to closed captions in video games.

Closed captions differ from subtitles, and are used to replace all meaningful sound in a video game, including dialogue and sound effects.

Figure 2 demonstrates the use of closed captions in Portal 2, with character speech displayed as grey text, and sound effects as white text, enclosed in square brackets.
Do you use closed captions in video games?
- Yes, I always turn on closed captions.
- I turn on closed captions if they are enabled by default or otherwise want them turned on.
- No, I never turn on closed captions.

What are your reasons for enabling closed captions?
(You can select multiple)
- Helps me understand when characters speak too quietly
- Speech is a second language
- Helps me understand character speech
- Helps me understand the story
- Sometimes have difficulty understanding character/assistant
- Need to miss any crucial information

What are your reasons for not using closed captions?
- I never use them
- The games I play don't use or, unless, meaningful dialogue
- I find them difficult to read
- I'm too busy playing the game
- Other

Please answer the following about your experiences with subtitles and closed captioning:

<table>
<thead>
<tr>
<th>Subtitles are available in the games I play.</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>All of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed captions are available in the games I play.</td>
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<tr>
<td>Subtitles help me to play games.</td>
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<tr>
<td>Closed captioning helps me to play games.</td>
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<td>I find games more enjoyable with subtitles.</td>
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<tr>
<td>I find games more enjoyable with closed captioning.</td>
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</tbody>
</table>

Please answer the following about your opinions of subtitles and closed captioning:

<table>
<thead>
<tr>
<th>I prefer subtitles to closed captioning</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>More games need to use subtitles or closed captioning</td>
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<td>There needs to be a standard to define closed captioning and subtitles in video games.</td>
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<td>Closed captioning should be mandatory in video games.</td>
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<td>Subtitles should be mandatory in video games.</td>
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<td>I would like to see a different way of conveying audio in video games.</td>
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</tbody>
</table>
Do you know of any other in-game options that provide audio information in another way?

☐ Yes (describe)  ☐ No

Do you have any other comments or questions?