

Inclusive design in a virtual world serious game to improve adult literacy: Problems, possibilities and tensions

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Use of theoretical frameworks can be powerful reflective thinking tools when developing new digital tools for learning. For maximum utility, digital learning tools should be designed to be inclusive of human difference. The purpose of this paper is to provide a case study on the application of an inclusive design framework in the development of a virtual world serious game designed to improve the literacy of learners in tertiary education. This paper provides a critical perspective on applying an inclusive design framework including problems, possibilities and ongoing tension in the project involved in deploying the game to both mobile devices and via head mounted display. Understanding both the strength and potential fallibility of theoretical frameworks such as inclusive design is important in developing impactful technological solutions to enduring social and educational problems.

Keywords: serious game, literacy, inclusive design, virtual reality, mobile learning, learning

Introduction

The purpose of this paper is to provide a case study on the application of an inclusive design framework in the development of a virtual world serious game intended to improve the literacy of adult learners in tertiary education. The literacy game, *Robo WordQuest*, can be deployed to smart phone, tablet and via virtual reality (VR) head-mounted display (HMD) (it has yet to be released and will be available free of charge). The game's main audience is tertiary students who have poorer literacy proficiency, an aspect of academic preparation often related to lower socioeconomic status, Indigeneity and rurality in the Australian context (Lamb et al., 2015). This paper provides a critical perspective on applying an inclusive design framework (Inclusive Design Research Centre, n.d) to the area of serious game development by identifying problems, possibilities and tensions in the project. The paper seeks to contribute to a more nuanced and empirical understanding of the strength and potential fallibility of theoretical frameworks such as inclusive design in developing impactful technological solutions to enduring social and educational problems. Firstly, the literature on adult literacy and serious computer games is briefly reviewed, before the principles and processes of inclusive design are outlined. A description of the serious game follows, including the processes used to inform its development. The application of an inclusive design framework to the development of a serious game is then detailed in terms of teasing out problems, possibilities and tensions. The paper concludes by suggesting that an inclusive design framework provides thinking tools and a road map for design; however, more fine-grained case studies of the approach are required to resolve problems and tensions.

The problem of adult literacy and computer games for language learning

Literacy is defined as 'as understanding, evaluating, using and engaging with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential' (OECD, 2013, p. 59). Large scale international surveys conducted by the Organisation of Co-operation and Development (OECD) indicate that around 18.5% of adults have poor reading skills and this affects their ability to function effectively in everyday life (OECD, 2016b). This result is supported by the Program of International Student Assessment (PISA) which shows that the percentage of 15-year olds who have low reading literacy proficiency is 19% in the United States; 18% in Australia; and 18% in Britain (Thomson, De Bortoli, & Underwood, 2016, p. 5).

Generally, literacy proficiency increases with years of formal education; however, research indicates that a not insignificant proportion of students enter tertiary (vocational and higher) education with poorer literacy and that some graduate without this being rectified (Moon, 2014; Wingate, 2014, 2015). Poorer literacy proficiency impedes learning and academic progress (Moon, 2014; Wingate, 2014) and feelings of shame and stigma can create a reluctance to seek help (Nicholas, Fletcher, & Davis, 2012). Tertiary students with poorer literacy proficiency do not necessarily come from linguistically diverse backgrounds; they can be native speakers with



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research highlighting how widening participation policies in higher education have presented challenges for universities who can no longer assume younger or mature age students commence study academically prepared (Klinger & Murray, 2012; Murray, 2013).

Research has been conducted on the efficacy of computer games for improving language proficiency, particularly in the area of second language acquisition (see Peterson [2013] for an overview). This includes computer games specifically designed for educational purposes, also known often called 'serious games'. There is some evidence that serious literacy games can be highly motivating and effective in meeting learning outcomes (Smith, et al, 2016) and that the effectiveness of serious games can generally can be enhanced if games are selected by educators according sound pedagogical principles and curriculum alignment (Southgate, et al, 2017). Research has documented how recreational 3D virtual game worlds can assist in language acquisition through multimodal communication through situated or embodied cognition and via the affordances of the technology especially online interaction (Pasfield-Neofitou, 2014; Peterson, 2013; Rama et al., 2012).

While there are some serious game virtual worlds designed for children's second language acquisition (Sørensen & Meyer, 2007), we have been unable to identify similar serious games for adult language learning. This gap in the market, along with the relatively recent advent of highly immersive virtual reality, mediated through more affordable HMDs, offered a unique opportunity to develop an engaging serious game that tertiary education students could play to improve their literacy. The literature suggests that for increased uptake and learning effectiveness such a game would need to be inclusive and respectful of students' socio-cultural diversity, be gender inclusive, and integrate gaming and aesthetic features that appeal to a variety of users (Scott et al., 2003; Barab et al., 2005). Hence, the interest in identifying an appropriate inclusive design framework to guide the development of the literacy serious game.

Inclusive design

Historically, inclusive design has its roots in ensuring that designers respond to the needs of the widest possible audience irrespective of age or dis/ability (Clarkson & Coleman, 2015). It is increasingly used as a framework for understanding and engaging with a broad range of user diversity including dis/ability, age, language, culture, gender, and other forms of human difference (Inclusive Design Research Centre, n.d.). Its importance is captured by Waller et al. (2015) who remark: 'Every design decision has the potential to include or exclude customers' (p. 297). The interrelated dimensions of inclusive design are represented in the following theoretical framework (see Figure 1):

According to the Inclusive Design Research Centre (n.d), these dimensions entail:

1. *Identifying broader beneficial impact* of design decisions by realising that inclusive design decisions can have positive benefits beyond their immediate target. This is called the curb-cut effect (Blackwell, 2007) named after the action of disability advocates in the 1970s who poured illegal concrete ramps to create access for wheelchairs, an action that prompted the major redesign of pavements and improved pedestrian access for all. By recognising the interconnectedness of users and systems and increasing the diversity of user perspectives, designers can make changes that facilitate a 'virtuous' (rather than an adverse) series of changes that can have far reaching positive impacts on people's lives.
2. *Using inclusive process and tools* involves an open, participatory approach involving individuals who have lived experience of the issue having direct involvement in the framing of the problem and its possible solutions. This means respecting the edict 'nothing about us without us.'
3. *Recognising diversity and uniqueness* from the hypothetical 'average' to include those who are considered at the margins. This is undertaken to better understand the needs and goals of an individual or group. Solutions should be flexible or adaptable but rarely includes specialized or segregated options. Autonomy, self-determination and self-knowledge are key to this.



Figure 1: Dimensions of inclusive design (Inclusive Design Research Centre, n.d).

Overview of the game *Robo WordQuest* and the development process

An interdisciplinary team, with expertise in software engineering, education and Indigenous culture, worked in consultation with students and staff at X university to design *Robo WordQuest*. In all 16 staff (5 Indigenous, 10 non-Indigenous) with a minimum of 2 years teaching experience participated in staff focus groups. Forty-two students (12 Indigenous, 30 non-Indigenous), who were undertaking enabling and undergraduate study, participated in student focus groups. Focus groups were facilitated by two members of the research team and were guided by a schedule of questions on: key areas for literacy improvement; type of game and design preferences; and experience using games for learning. Focus groups were between 1-1.5 hours in duration with students receiving a \$30 supermarket voucher for their time. The project had institutional ethics approval (approval number H-2017-0115).

During the focus groups, students and staff identified the preferred literacy foci for the game as punctuation (apostrophes, commas and full stops, and colons and semi-colons) especially to 'fix run-on' sentences, and basic paragraph structure. The focus group with Indigenous staff guided the team to explore inclusive approaches to design as this group expressed a preference for the subtle weaving of Indigenous cultural elements into the gameplay (for example through the integration of Aboriginal art) and the use of side missions or quests. The issues raised in applying an inclusive design process are discussed later in this paper in Table 1.



Figure 2: Screenshots of the interior of spaceship with its life support system panel with a collectable pop-up (left) and the yellow dimension with a diving board to access a floating platform with the literacy exercises (right).

Robo WordQuest is based on a science fiction scenario, a preferred genre amongst undergraduate students we spoke to as in the focus groups we held as part of the design process. The narrative is that a spaceship has crashed on an alien planet. The player, in first-person view with their friend (a non-player character robot dog), must explore different dimensions of the planet so that they can gather 'energy cell' collectables that can repair the ship. From a design perspective, the game has three zones: (1) the spaceship which the player can teleport to and from and which houses the energy and life support systems that populate with energy cell collectables as the player completes literacy exercises, exploration and item collection side missions; (2) a planet with three different coloured dimensions (blue, green and yellow) which consists of hills, lakes and ravines to be freely explored; and, (3) floating platforms within the dimensions which comprise training videos and literacy mini-games that can be accessed by jumping off diving boards that propel the play upward (see Figures 2). Player monitor their progress through the display of energy cell collectables on achievement boards, represented in game as the energy and life system panels. The game was developed using the Unreal Engine 4.

The three dimensions of the planet are accessed via portals located in different parts of the spaceship. Each dimension is dedicated to a different set of literacy content: The green dimension is for playing games related to apostrophe use; the blue dimension is for games related to other types of punctuation (full stops, commas, colons and semi-colons); and the yellow dimension is for paragraphs. Mini-games are on floating platforms in the virtual world (see Figure 3) and are organised according to different levels of difficulty, except for paragraphs which are divided into three groups of exercises of similar difficulty.

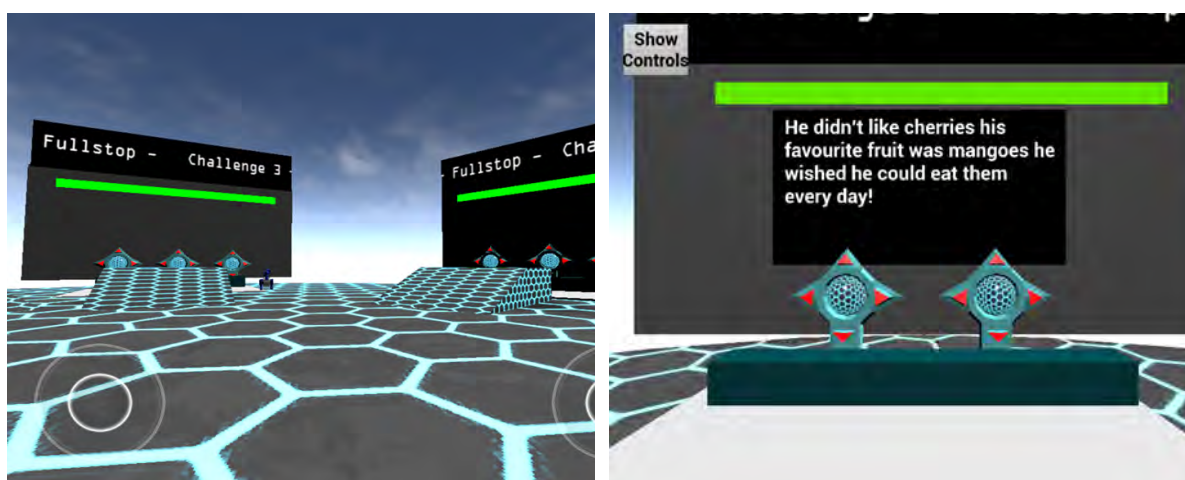


Figure 3: Screenshots of the literacy exercise platform for full stops (left) with sample exercise (right).

Upon completing all the literacy mini-games on each platform and after side-missions, the player is offered a choice of three collectable energy cells which plug into the ship's broken energy and life support panels (see Figure 4). Game customisation was highlighted as desirable in the student focus groups. In *Robo WordQuest* the player gets to customise the look of the life support system panel by selecting energy cell design of choice. A third of the energy cell collectables are designs from Aboriginal artist Saretta Fielding featuring Australian fauna and Aboriginal designs (Figure 4 right).



Figure 4: Example collectable energy cells: circuit (left), gem (middle), and Aboriginal design for koyiyoong or campsite (right).

Using an inclusive design framework in the development of *Robo WordQuest*

The role of any theoretical framework is varied. Theoretical frameworks can generate hypotheses, are lenses for interpreting phenomena and can be a guide to action. Powerful theories operate as explanatory tools at micro, meso and macro social and systems levels (Bronfenbrenner, 1979). The inclusive design framework from the Inclusive Design Research Centre (n.d) functions are both a set of principles for generating social good based on valuing and recognising diversity and as a means of acting in the world to do this. When applying the inclusive design framework in developing the literacy serious game both its strengths and limitations became apparent, particularly in relation to pragmatic issues such as time constraints and authentically engaging with gender diversity for design. Table 1 maps some the problems, possibilities and tensions that have been encountered during the project.

Table 1: Use of the inclusive design framework in the development of *Robo WordQuest*

Inclusive design dimension and project approach	Problem, possibility, tension
<p>1. Broader beneficial impact</p> <ul style="list-style-type: none"> interconnectedness of users and systems virtuous cycle of inclusion impact beyond intended audience <p>The project has the potential to a broad beneficial impact on a major issue, lower literacy proficiency and how this impedes academic success and life opportunities. It recognises that students of all ages will have gaps in their literacy knowledge and that a free mobile learning tool could allow students to improve their skills.</p>	<p><i>Problem:</i> Societal induced shame about low literacy proficiency.</p> <p><i>Possibility:</i> Mobile learning tools such as serious games enable students to improve their literacy in privacy and at their own pace, alleviating feelings of shame.</p> <p><i>Tension:</i> Digital inclusion - Many students affected by lower literacy proficiency come from economically disadvantaged backgrounds. While most have mobile devices, these may be older models with lower specifications, and these students often have very limited data plans. The game would need to run offline and on older devices. The economic circumstances of students would mean that those wanting to use the HMD version may not have access.</p> <p><i>Possibility:</i> Developing curriculum material and case studies on the pedagogical potential of the HMD version of the game may prompt institutions to invest in HMDs for classroom and learning support use. The game development platform Unreal Engine 4 provides a build-once-deploy-many approach to support a VR version for HMD smartphone hybrids, for example Samsung Gear VR. This may provide increased opportunity for students or institutions to purchase an affordable HMD.</p>

	<p><i>Possibility:</i> As literacy proficiency is not necessarily age related, there is potential for the game to make an impact beyond its intended audience in the tertiary education sector; schools may be interested in including it as part of English and specialised literacy programs, especially as it is free of charge and attractive to Indigenous and non-Indigenous children alike. Promotion of the game to the school sector will be the main challenge.</p>
<p>2. Using inclusive processes and tools</p> <ul style="list-style-type: none"> • diverse participation and perspectives • accessible design and development tools <p>The project used a participatory design process to seek input and feedback from potential users. User input was facilitated through focus groups with university students and staff from Indigenous and non-Indigenous backgrounds. The leads on the project are from Indigenous and non-Indigenous backgrounds. Students from rural areas were specifically targeted during focus group recruitment.</p>	<p><i>Problem A:</i> Inadequate gender representation. While there was good participation of staff and students from Indigenous and non-Indigenous backgrounds, gender diversity amongst student participants was lacking. In all 27 identified as male, 14 as female, and 1 as other. Gender representation was best amongst Indigenous students with 6 participants identifying as male, 5 as female, and 1 as other.</p> <p><i>Possibility A:</i> There was originally an opportunity to recruit more female students for focus groups however, the time limited nature of project funding meant that much of the game mechanics and interface preference decisions had already been made by the time additional focus groups could be organised. Instead, the female researchers on the project made informed decisions regarding the aesthetics and narrative of the game in the hope of making it appealing to women (e.g. having a non-phallic shaped space ship, having gender-neutral first-person perspective, having the main non-player character be female and the captain of the space ship, and eschewing violence in gameplay).</p> <p><i>Tension A:</i> Funding stipulations and the compressed nature of the academic year affected initial decisions on responding to gender inclusivity in the design process. This raises the question of how to best avoid essentialism in the design process. Essentialism refers to the attribution of fixed or essential characteristics or qualities to binary categories of gender (i.e. girls are innately caring, boys are innately tough) (Heilmann, 2011). Making design decisions without appropriate gender representation (and beyond binary gender categories) in the consultative process can potentially result in the perpetuation of stereotypical understandings of gender design preference.</p> <p><i>Problem B:</i> Potential for cultural appropriation. Cultural appropriation is defined as the taking of ideas, cultural expressions, ways of being, symbols and artefacts from another culture and uses these to further one's own ends (Rogers, 2006) and it is present in some recreational computer games (Nash, 2016).</p> <p><i>Possibility B:</i> Weaving Indigenous perspectives into game design is possible if there is respect for Indigenous ways of knowing, doing and being (Martin & Mirraoopa, 2003) and the team authentically includes and involves Indigenous people. This is vital because only Indigenous people will know or have the cultural connections to inquire about what can be respectfully, rightly and correctly represented in a game including cultural symbols. This also involves the right of Indigenous people to protect knowledge (see Principle 4 https://aiatsis.gov.au/research/ethical-research/guidelines-ethical-research-australian-indigenous-studies/rights-respect-and-recognition).</p> <p><i>Tension B:</i> Non-Indigenous game designers need to undertake ongoing Indigenous consultation throughout the process to ensure that cultural appropriation does not occur, and respectful relationships are built and maintained. While ongoing consultation fits with agile or participatory design models, there are often project time constraints which, if not properly managed, have the potential to circumscribe cultural consultation processes. Building in ongoing consultation processes need to be considered early in the project planning stage.</p>

	<p><i>Problem C:</i> At present the complexity of coding and other technical aspects for an open world game environment, even with game engine and internet-related support (e.g. YouTube instructional videos), limits the general accessibility of development tools. This will undoubtedly change in the future. However, participants were limited in this project to providing initial input on content and game design preferences, with Indigenous students also providing feedback on art choices for the energy collectables.</p>
<p>3. Recognising diversity and uniqueness</p> <ul style="list-style-type: none"> • one-size-fits-one • adaptive design • self knowledge <p>A virtual world, where autonomous, fun and flexible exploration is encouraged, offers an ideal environment for uniquely individual self-paced learning, provided that appropriate feedback and 'just-in-time' scaffolding can be incorporated in the game. Learning theory suggests that scaffolded guided discovery coupled with the visual and doing (non-verbal) affordances of a serious game in both mobile device and HMD experience, will allow learners to dual code (Clark & Paivio, 1991) new literacy knowledge and refresh previous (self) knowledge.</p>	<p><i>Problem:</i> The decision to deploy the game to both smart devices (phones and tablets) and HMD VR raised the question of duty of care towards potential users in relation to the issue cybersickness (also known as simulator sickness or VR sickness) and other potential hazards such as eye strain, dizziness or loss of balance etc. There appears to be no clear predictor for who will become adversely affected or cybersick when using a HMD, although it is possible to design movement techniques in order to minimise it (LaViola et al., 2017). Whatever the engineered solution, the highly individual nature of cybersickness make it incumbent upon developers of social and educational technologies to provide clear, accessible information on risks.</p> <p><i>Possibility:</i> Building cybersickness information and warnings into the game deployment platform or as an in-game pop up may educate on cybersickness and mitigate risk. There needs to be explicit age-related warnings regarding deploying the game to HMD VR: this need to be in line with current hardware warnings (not suitable for under 13 years) and research recommendations (Southgate, 2018).</p> <p><i>Tension:</i> Commercially available, affordable HMDs are now easily available, however VR mediated through HMDs are still a novel technology with public knowledge about cybersickness not widespread. Even with educational material and warnings, users may not understand or heed this.</p>

Conclusion

The inclusive design framework (Inclusive Design Research Centre, n.d) was valuable in theoretically framing the inclusive intent of *Robo WordQuest* within a broader context of stigma related to lower literacy proficiency and for considering the range of potential users including university staff who might recommend or use it in their teaching, students from diverse equity groups, and, potentially (when considering a virtuous cycle of inclusion), school students. With its three dimensions and ten sub-dimensions, the framework provided a road map (dimensions) with check-points for action (sub-dimensions) in what was a complex development process involving culturally sensitive respectful interaction. Moreover, the framework also delivered a set of powerful reflective thinking tools that could be deployed during and at the end of game development. Its utility as a framework was tested when the team encountered a range of situations that required a pragmatic response especially time constraints which impeded the recruitment of additional female and non-binary gendered students to inform the design, and a lack of time to properly enact cycles of participant input and product feedback during the project. Advancing the use of inclusive design in the field of serious games and in the creation of other digital learning tools will require more fine-grained case studies which systematically detail and reflect upon its usefulness and limitations in the complexities of design and development.

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