Establishing reasonable adjustments for creating gamified learning interventions which are accessible to children with autism and enhance their user experience.

Daisy Malbon
1827014

Cardiff University
School of Computer Science and Informatics

2021

Abstract:

Gamified learning interventions, also called Serious Games, are engaging virtual environments or simulations which feature an educational purpose and design. In academic settings serious games have become a commonly used learning tool due to their entertainment feature to which children respond well. Due to their rise in popularity within this decade alone, studies and investigations have taken place to determine their appropriateness for all children, including neurotypical children and those with autism. If game designers wish to target children with autism, they must incorporate reasonable adjustments into the game's core principles. Therefore, throughout this report I will be outlining my criteria which gamified learning interventions should follow to be suitable for users with autism. This was also assessed by autism professionals, which enabled me to conduct a thematic analysis. Once my thematic analysis has been coded, analysed and therefore completed, using my conclusive criteria I will design a checklist for the purpose of evaluating existing games. Each criterion will be judged to be either: fully implemented, partially implemented, not implemented or not relevant. The checklist will then provide each game with a percentage which will indicate its degree of suitability for use with children with autism.

Key words:

Autism, ASD, Serious Games, Sensory Processing, Brightness, Timed response, Information processing, Social Stories, Forfeits, Frustration, Shutdown, Reward, Triggers, Bottom-Up Thinking

Introduction:

Children with autism process information in a different way from other children. Common characteristics which children with autism demonstrate include: Sustained repetitive play, avoidance of eye contact, a preference for being alone, an insistence on sameness, an inappropriate reaction to sound and difficulty relating to other people (Collins, 2019). The attributes listed above strongly suggest that children with autism would respond especially well to a computer-based environment, which can be considered a safe and comfortable setting within which they can learn and even feel secure enough to make mistakes; in a real environment this could lead to extreme distress (Kulman, 2018). Research proves that children with autism are attracted to computers for three main reasons: absence of social factors, consistency and predictability, and control. As children with autism respond well to virtual environments, there are already established technologies to enable children with autism to improve social interactions and develop language skills (Abirached et al, 2012).

Because computer games represent a sympathetic environment for children with autism given the reasons above, such children can spend a disproportionate amount of time on computers. Studies have shown that children with autism spend double the amount of their free time playing video games in comparison to neurotypical children (Mazurek and Engelhardt, 2013). There are three times as many boys as girls diagnosed with autism and boys are particularly, but not uniquely, attracted to video games. Therefore, it would be beneficial to harness this enthusiasm to promote psycho-social outcomes via game play. There are two factors to consider regarding games for children with autism: to what extent can existing serious games be adapted so that they are suitable for the needs of the child with autism and how can games be specifically designed for children with autism to teach certain goals and life skills. Within this project, I will pay particular attention to serious games; I will be focusing on the direct benefits that serious games aim to teach, as well as secondary benefits such as communication skills, social interaction and self-awareness.

Background:

Autism is a pervasive, developmental disability which can affect one's communication and connections within their perceived environment. According to the Office for National Statistics (2021) there are 700,000 people in the UK who experience Autism; of these 143,500 school aged children have an Education and Health Care Plan which lists autism as their primary need. However, there are only 646 schools in the UK with approved autism provision. Approximately 1 in 100 children in UK schools experience autism. It is clear therefore that educators and other caregivers need access to carefully designed materials to improve outcomes for children with autism. Such materials would include 'serious games.'

Serious games (SG) use the recognised conventions and design elements of conventional video games and combine these with principles of learning and social development (De Freitas 2006). Recently it has been theorised that the most successful learning takes place in more active, experiential and problem-based conditions which can also provide immediate feedback to the user (Boyle, Connolly & Hainey, 2011). These features can effectively be offered through Serious Games.

Yusoff (2010) defined a conceptual framework describing the essential attributes for serious games using psychological approaches to learning such as behaviourist theory, cognitive theory and constructivist theory. The attributes listed include: "incremental learning, linearity, attention span, scaffolding, transfer of learned skills, interaction, learner control, practice and drill, intermittent feedback, reward, situated and authentic learning, and accommodating the learner" (Grossard et al., 2017). The descriptions of each attribute are outlined in the table below and I will be looking to find these attributes in the games I evaluate.

Table 1 Yusoff's Scale

Attribute	Description
Behaviourist Theory	
Interaction	Engagement in the game for the user
Reward	Provides incentive for the user
Practice and Drill	Taught skill is repeated in the game
Cognitive Theory	
Incremental Learning	Given tutorials, examples, and hints in game
Linearity	Increasing level of difficulty
Attention Span	To keep concentration high, game has short duration per level
Transfer of learned skills	Application of skills in different environments
Constructivist Theory	
Scaffolding	Support is offered to the user throughout the game
Learner Control	Choices offered in game, for example duration
Psychology Theory	
Situated and authentic learning	Context offered in game
Accommodating the learner	Choice to personalise aspects of the game
Intermittent Feedback	Feedback offered per level completed and throughout game

Methodology

To ascertain my criteria, I needed to define the parameters of my research. This would include my search terms, which are specific words that will provide my initial range of resources. However, once I established the primary list of resources, I needed to narrow this down using Inclusion/ Exclusion Criteria, shown in Table 2. Thirdly, with my focused selection of research I could develop my criteria which I then used to evaluate my selection of games. Finally, I carried out a thematic analysis to discuss findings and methodology with experts in autism.

1. **Search terms**

My data collection dealt with characteristics of autism in children and suggested suitable adjustments that could be implemented within a gamified environment. It was also important for me to find research regarding children with autisms' reaction to certain stimuli. For example, if a child with autism has hypersensitive hearing of specific frequencies, high pitched noises can invoke a pained response, therefore this is something that should be avoided or provided with a warning in serious games. Hypersensitive hearing of specific frequencies is often associated with autism (Wang, 2014).

2. **Inclusion and Exclusion Criteria**

To be included in the review, the resources must:

a) Date from 2002 - 2021 if the topic of the paper was regarding autism in children. Ideally, more recent resources would only be included as earlier papers may be somewhat outdated, such as by using terminology which could now be considered incorrect, for example referring to autism as a 'disease', rather than a condition. However, I have referenced journals or books from before 2000 only if they have been included or referenced in more recent papers which fit my inclusion criteria. Sources regarding the topic of serious games will be excluded if they are dated from 2005 or earlier as the technology used will be irrelevant to more recent gamified interventions, as technology has advanced significantly since then. Earlier sources will be referenced only if they have been mentioned in more recent papers as well.

b) Specifically regarding autism in children or serious games. Papers would not be included if their topic was autism in adults, neurotypical children or non-educational games.

c) In English. Arranging translation would have been a difficult task and only necessary if the paper in question included a very specific clinical outcome relevant to my review.

d) Personal accounts featured on authoritative sites, such as the National Autistic Society, and peer reviewed articles.

Table 2 Inclusion/ Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Journals, Websites or Books from 1994 - 2020	Studies only relevant to adults with autism
Regarding autism in children OR serious games design	Studies not explicitly mentioning children with autism OR serious games
English Language	Studies not relevant to 3–15-year-olds with autism
Peer Reviewed	Studies about non-educational games

3. Creation of Criteria and Checklist

My criteria, which Serious Games should follow to be suitable for users with autism, will be determined by the resources gathered from my systematic search and my insights of how game designs can offer reasonable adjustments regarding the symptoms and reaction to stimuli for children with autism. However, also taking into consideration the attributes that Yusoff (2010) considers essential for a game to be classified as serious.

Once the criteria have been created, I will be able to form a checklist that will enable me to quantify the results. Each criterion, which will be judged as either fully implemented, partially implemented, not implemented or not relevant within the game, will have a score:

- Fully implemented = 2 points
- Partially implemented = 1 point
- Not implemented = -1 point
- Not relevant = 0 points (no effect on overall score)

I will also form a checklist from Yusoff's scale, as demonstrated in Table 1. Yusoff's criteria were designed to define serious games, but not within the context of autism. I wanted to use his criteria to ensure that the games I evaluated were indeed Serious Games, and use these alongside my own criteria, to ensure that the games were also appropriate for children with autism. I will quantify the outcome using the same method as is listed above.

4. Process of Selecting Games to Evaluate

I selected serious games using various search terms, which included:

Serious Games, Educational, Interactive, Database, Online

However, I found very few results using this method and therefore struggled to complete an established procedure for data collection. However, through my research I discovered the Serious Games Company™. The CEO and founder of this company, Juliette Denny, had recorded her 'Top 10 Serious Games' (Denny, 2019), therefore I decided to combine elements of her suggestions with my own selection and evaluate this list of gamified learning interventions against my and Yusoff's criteria.

All Games are available on either iOS, Android, PC or Browser and are appropriate for children aged 7 and above.

The games that I will evaluate are:

Minecraft™

Minecraft is a java-based multiplayer sandbox game, which is child friendly and in first person (Ekaputra, Lim and I. Eng, 2013). It was designed and developed by Mojang Studio, and whilst Mojang states that Minecraft was "designed to have no set goals or objectives, leaving players to explore and create" (Kuhn, 2017), there are self-evident educational elements, such as three-dimensional visualisation, socio-geography and architecture. Educational environments globally have begun to implement Minecraft as a teaching tool (Ekaputra, Lim and I. Eng, 2013).

Most importantly, Minecraft has been used to encourage the use of social skills for children with autism. Zolyomi and Schmalz (2017) showed that the Minecraft environment enables social learning as it allows children to practice modelling, attention to detail, imitation, and creation.

LightBot™

LightBot™ is an educational game developed using Javascript and created by Danny Yaroslavski in 2008, with the purpose of teaching software programming concepts. It offers a very simplified environment for the user. In the game, the user must give a robot a series of simple instructions, such as turn, move forward and jump, to light up the blue blocks on a board (Gouws, Bradshaw and Wentworth, 2013).

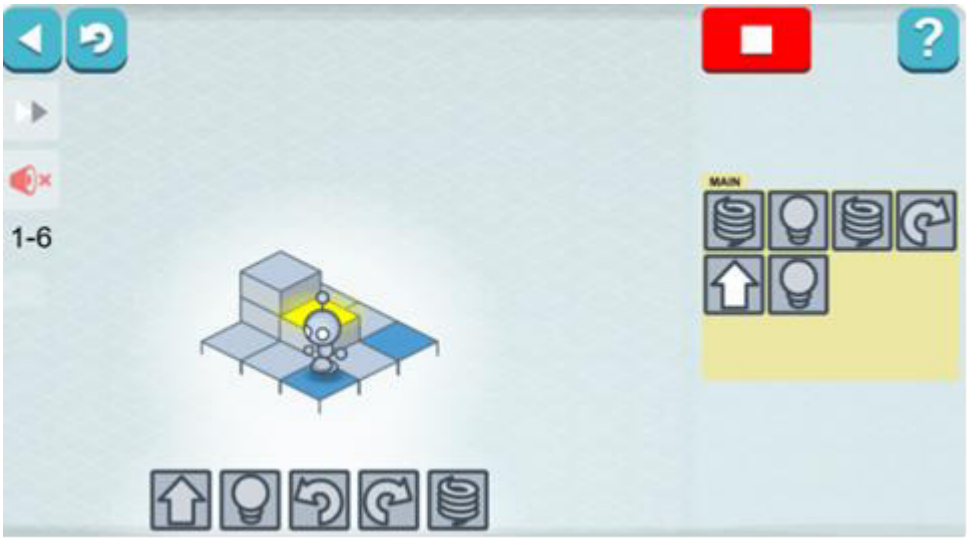


Figure 1 Example Image from lightbot.com

Re-*Mission 2: Nanobot's Revenge*

Denny (2019) references the original Re-Mission game in her list, however only the second edition was available to me. This serious game was published by Hopelab in 2013 and is a particularly inspiring game, with the intention of helping younger cancer patients with treatment compliance (Omidyar, 2013). In the game the user has to fire 'treatments' onto a growing tumour present on the screen, to win and move onto the next level one must diminish all of the nuclear tyrants, which represent cancer cells. The user can also win achievements by using tactics such as 'preventing a tumour from reaching floor 3'.

Fate of The World

Fate of the World was released in 2011 and developed by Red Redemption. The game's storyline revolves around various global warming scenarios, such as 'save the amazon' or 'fuel crisis'. In this simulation, "users are directed to solve clear and specific problems, and although multiple approaches to a problem are possible, it is difficult to get side-tracked from the game's goal of coming to understand social systems" (Waddington, 2015). Overall, the core goal of the game is to stop the global temperature from rising more than three degrees.

Figure 2 Example Image from the 'Oil Crisis' scenario (Fate of the World on Steam, 2011)

Whyville

Whyville was founded by Dr James Bower and his students at the California Institute of Technology. Created in 1999 and updated regularly since, Whyville is a virtual, simulation-based world which includes around 100 educational games to play. "The Whyville world supports exploration, communication, interaction, real world problem solving, and science education as users participate actively in learning by completing science activities and games" (Galas and Sun, 2007). In the virtual Whyville world, the user plays as an avatar which they can design using various features. Whyville also has a 'chat' feature where users can talk to one another. It is important that young users understand the risks of talking to strangers online as they are vulnerable. Whyville insists that the user gains a 'chat license' before being able to talk to others through the game. This includes a step-by-step guide for the user in the case of another player asking for personal details, for example: if someone asks for your address, press 'report'.

Figure 3 Example of a 'Chat License' from the game Whyville, (Whyville.net, 1999)

SimCity™ 4

SimCity 4 was developed in 2003 by Maxis and is a single-player simulation computer game where the user is given the task of urban planning and development of a city. “SimCity 4 makes the player both mayor and city planner so that they can design and build the city they want” (Minnery and Searle, 2013). This game is not only effective at teaching simple geography concepts such as urban development, but it also helps students to develop knowledge in a strategic manner, so they can see both the short- and long-term effect of their decisions and aids improvement in critical reasoning and thinking (Minnery and Searle, 2013).

Chill Panda

Chill Panda was developed by Onteca and released in January 2021. It is designed to help reduce anxiety and illustrate to children’s strategies to cope with stress, such as breathing techniques, yoga and mindfulness.

Figure 4 Image Screenshot from Chill Panda App, 2021.

In a systematic review conducted by Hwang and Kearney (2015), they found that the implementation of mindfulness led to “reductions in obsessive thoughts” (Brown & Hooper, 2009) and also “reductions in anxiety” (Idusohan-Moizer, Sawicka, Dendle, & Albany, 2013; Spek, van Ham, & Nyklicek, 2013). Therefore, to experience a child-friendly app which age-appropriately teaches mindfulness techniques seems very effective, especially if handled in such a way which also makes it accessible to children with autism.

DragonBox Elements

DragonBox Elements is part of a mathematical gaming series developed by Kahoot DragonBox AS and published in 2014. DragonBox Elements has a mathematical- educational design and its purpose is to teach children how to draw and recognise various shapes and angles. There is an underlying storyline within the game that the user must free the characters stuck in the shapes and if they effectively do so, the characters join the user’s ‘army’ (Carmichael, 2017).

“The goal of the Dragon Box Elements Triangles game is to find and build triangle shapes, based on properties of equal sides, equal angles, and right angles. Users identify and trace triangle types, including scalene, isosceles, and equilateral” (Moyer-Packenham et al., 2019)

Figure 5 Example Image from DragonBox Element App, 2017

Dream Hospital

The game that was suggested by Denny (2019) called 'Pulse!!' is designed for medical professionals in training, therefore not particularly appropriate for children. Alternatively, I will be evaluating the serious game 'Dream Hospital' which shares the same themes as 'Pulse!!' but within a more child-friendly environment.
Dream Hospital was published by Yboga and released on Android and iOS in 2018. It is a simulation game where the player is expected to organise and manage a hospital, whilst also becoming the 'best' doctor at the hospital. This involves building advanced medical tools such as x-rays, producing medicines and competing with different hospitals.

Escape the Pacific

This interactive, sand-box survival game was released by the Gamers4Gamers Team in 2018. The user must design a water vehicle to escape an island that they have been trapped on, whilst also facing difficult weather conditions. The game offers six different game scenarios: normal, hot, wet, cold, windy or calm. There's a 'Story Mode' option, where the player must survive alone, or a multiplayer mode to choose from.

This is the definitive list of games that I have chosen to evaluate.

5. Thematic Analysis: Generating Themes and Codification

A thematic analysis is a qualitative method used for processing and analysing large quantities of data (Nowell, Norris, White and Moules, 2017). I will use this to identify patterns within my dataset, which consists of interview transcripts that I have gathered from professionals in autism. The participants I have gathered to interview are:

a. Expert 1. A forensic psychologist who has worked with people with autism and with several professionals who are specialists in autism, such as social workers, speech and language therapists and clinical psychologists. They have also sat on a national task and finish group by the British psychological society devising criteria for working with people with autism for psychologists all across the UK.
b. Expert 2. A Senior Lecturer in the field of Psychology who focuses on autism research. They have also worked with the Welsh Government in terms of helping them think about autism.
c. Expert 3. The managing director of an organisation which provides a screening tool to screen for all new and diverse conditions to be able to support children in schools, people in prisons and employment.

d. Personal Profile. A parent to three children, including an eight-year-old with autism and Attention Deficit Hyperactivity Disorder (ADHD). They will be able to offer a personal insight into the necessary adjustments that they make when educating a child with autism, compared to a neurotypical child.

Each interview will be structured and recorded. A structured interview is one where all questions are predetermined and the same for each interviewee, except for the Personal Profile where the interview will be semi-structured. The interviews being recorded will allow me to transcribe the audio after the interview has been completed. Transcribing will let me familiarise myself with the data I have collected, and therefore make the process of codification more manageable (Caulfield, 2021).

To code qualitative data I used a deductive approach, meaning that it is based on my existing theory. For this, I will highlight certain phrases in a variation of colours. The colours chosen will correspond to what I feel was expressed in that specific section of the text.
The codes and associated colours are:

Environment
Focus
Sensory
Language
Meltdowns
Inclusivity
Personal
Context
Tasks
Feedback

The resulting collation of data will give me a "condensed overview" of the recurring codes and insights within the transcripts (Caulfield, 2021).

From the recurring codes, I can congregate themes which appear. Themes are a combination of several codes. For example, Uncertainty and Conflict may fall into one theme, labelled 'Unreliable'. As Caulfield (2021) states, "we want to create potential themes that tell us something helpful about the data for our purposes". It is important that the themes I have generated truly represent the data collected. Once all my themes had been agreed upon and data had been assigned to each, I was able to summarise the findings and make the necessary changes to my criteria and checklist, with regards to the quantified opinions of my participants.

Through the process of codification, I found 4 common themes within my data collection. These themes are as follow:

- Supports Theory
- Challenges Theory
- Unreliable.
- Insight, which is a suggested change to the criterion that I have gathered through data processing.

6. Quantifying Results from Conclusive Criterion

The games listed throughout Section 4. will be moderated against two criteria. For my definitive criteria which could have altered due to the results from my thematic analysis, there will be a maximum score of 78 points which the serious games can achieve. For Yusoff's scale there will be a maximum score of 24 points. This will enable me to determine what percentage score the games I evaluate achieve in terms of their appropriateness for children with autism, and whether it contains the relevant attributes to classify as a Serious Game.

I will regard any game which scores over 40% on both mine and Yusoff's scale as fulfilling both criteria.

Criteria of reasonable adjustments for creating Serious Games and supporting Thematic Analysis:

Once I had completed my research, I was able to establish my definitive list of criteria; these are as follows:

1. **Option to modify the sensory environment within a virtual serious game.**

Nearly all children and adults with autism struggle with modulating sensory inputs, making it one of the most common characteristics of autism. A deficiency in auditory processing, the ability to process sounds, is one sensory processing impairment typically noted. Greenspan and Weider (1997) found that in a retrospective chart review of 200 cases, 100% of participants showed difficulty in auditory processing (Tomchek and Dunn, 2007). Studies by various authors such as Bettison (1994) and Dahlgren and Gilberg (1989) noted hypersensitivity to auditory stimuli to be common in children and infants with autism, meaning that louder noises can cause anxiety or discomfort. Over-responsivity to auditory stimuli can even be triggered by background sounds that most children or adults can easily filter out, this is called Hyperacusis (Wang, 2014).

Contrarily, there may be under-responsivity to auditory stimuli (auditory input seeking), where a child does not register auditory input within their environment. For example, not responding to someone calling their name. Children with autism who are auditory input seeking may seek background noise within a virtual serious game environment. Mayes and Calhoun (1999) found from a study with 143 children with autism that 73% of children with autism were unresponsive to auditory input (Tomchek and Dunn, 2007).

The first alleviation which can be made to help ease auditory over or under simulation is an option on the settings menu to mute sound. This way the child can feel more comfortable knowing that they have control over the auditory environment. I would also recommend a volume bar so the sound can be altered to the user's preference. If the child is in control of the volume, then the sounds they initiate are better tolerated (Grandin, 2006).

Visual sensory stimuli may also be problematic for some children with autism. Chamak, Bonniau, Jaunay and Cohen (2008) quoted Liane Holliday Willey, an adult with autism, who said that some of her visual triggers include: "Bright lights, mid-day sun, reflected lights, strobe lights, flickering lights, fluorescent lights; each seemed to sear my eyes. Together, the sharp sounds and the bright lights were more than enough to overload my senses".

Sensitivity to colours and colour contrast may also be a visual problem for children with autism. Some have reported that it can be difficult to look at certain colours as they make them feel queasy or even physically sick. Characteristically in children and adults with autism, enhanced sensitivity to sensory stimulation (Markram and Markram, 2010) influences colour perception, and this could result in a disinclination to view certain colours (Grandgeorge and Masataka, 2016). Colours which have been reported as especially discomforting include red, as the colour can be perceived as fluorescent, and yellow as it can be very overstimulating. Muted tones, such as greens, blues, pinks and neutrals can be very soothing however.

Before beginning the research on my chosen ten games, I wanted to evaluate a game that I knew was specifically designed for children with autism, as this would validate my criteria. An award-winning game called Prism, which was created to display social behaviours for children with autism, describes to the user that when the screen becomes too bright, and the user begins to feel overwhelmed they should hold down the 'f' button. This causes the screen's brightness to dimmer.

This deals with the concept of sensory overload and demonstrates repetitive, self-soothing techniques. The game was developed by Students from Carnegie Mellon University's Entertainment Technology Center and provides an excellent example of how modifications for users with autism may be implemented within serious games.

Figure 6 A demonstration of how Prism (2018) teaches coping mechanisms towards sensory overload.

This leads to the second modification for my criteria to make gamified learning interventions more accessible to users with autism, the option within settings to control the brightness of the interface. I would also suggest a selection of colour palettes, one being brighter colours and the second more muted tones.
If any flashing lights or images are included in the games, there must be a warning message. This is necessary not only for Autism Spectrum Disorder (ASD) but also other disorders such as photosensitive epilepsy or synaesthesia (the inability to differentiate from different senses). Ideally there would be an option to turn off any flashing images or lights in the settings for the serious game.

Supporting Evidence for Criterion 1.

When asked about how children with autism react to sensory stimuli, Expert 1 stated that “It’s commonly the case that people with autism have something called hypersensitivity to sensory stimuli, lights, sounds, even smells and taste. They can even be painful to them”. This supports my suggestions for sensory modifications within a gaming environment, such as the ability to mute background noise or implementing warning messages when the screen will be especially bright. Expert 1 also stated in favour of adjustments in games that “certainly in a serious game there can be an adjustment to particularly light and sound”. In my criteria there has been substantial focus on modifications within brightness and sound (this is reflected in the weighting of the criteria), as within gamified learning interventions these are the most common areas to cause unease for children with autism.

Expert 2 said that in educational settings some sensory problems that children with autism may experience have been considerably neglected. This includes finding lights difficult, noise, touch and other factors that neurotypical children may brush off. Expert 2 also introduced the idea of ‘camouflaging’, also known as ‘masking’, where a child with autism may hide their discomfort, therefore those issues are not given as much attention in a classroom setting as they can be

hidden. Hopefully in a gaming environment, which can be considered a ‘safe place’ for children where the need to hide their discomfort is less prevalent. Expert 2 conveys this in a comment, saying that children must suppress behaviours that they might use to help them manage anxiety in public settings, but this is lesser so in serious games. They also say how mentally exhausting it can be having to “exist in a normal system that doesn't sufficiently support them”.

Expert 2 discusses their research, which involves people with autism and giving control of a sensory room. “When they have control, they seem to do better in terms of their behaviours, fewer restrictions, less pestered behaviours and better attention”. This supports my idea to allow sensory modifications in games.

Expert 3 mentions how unappealing sensory stimuli can impact on a child's learning. “It can be the fact that they don't want to learn, they don't want to be back in that situation”. Therefore, to enable children with autism the opportunity to edit a sensory simulation to their taste can only positively impact learning.

The Personal Profile says that for children with autism it would be helpful if gamified learning interventions gave children a choice of background music and sounds. She said this will help as some may find certain frequencies and beats irritating but others may find it helps block out external noise and keep them engrossed in an activity. The idea of certain frequencies and noises being uncomfortable for children with autism is supported through research I found during my systematic analysis.

2. Option to choose level of difficulty within the gamified learning intervention.

To quote Fisher et al (2009), “one strategy for personalising training/ game play is to use adaptive progressions”. This means that the game will intuitively gauge the player’s ability which may vary from day to day (Whyte, Smyth and Scherf, 2014). The tasks and challenges to which the player can progress are limited by ability demonstrated earlier in the game. This means they are not presented with challenges which they may perceive as insurmountable and therefore lead to frustration, discouragement or even an exaggerated anger related episode or shutdown.

In addition to this technique of adaptive progression which is enforced by the game-play, is very important to permit choice and control within the game. To delegate control can help certain behavioural problems. Kern et al (1998) found from a review of the literature that it is effective “using choice as a distinct intervention, or as part of an intervention package, to decrease problem behaviours and/or increase adaptive behaviours in individuals with disabilities.” (Bogdashina, 2021)

An element of the game that can be personalised includes level of difficulty. However, this may provide issues for children with autism depending on their level of awareness of their own ability. Williams and Happé (2009a) stated “At least in some circumstances, self-awareness of mental states is more impaired amongst children with ASD than is awareness of mental states in others” (Williams, 2010). An ideal combination would be to merge the concept of adaptive progression and user choice. For example, based on in-game performance, users may be given access to a limited range of difficulty levels to prevent overestimation of ability and ensuing frustration.

<u>Supporting Evidence for Criterion 2.</u>

Questions regarding this criterion revolved around the feeling of frustration and the idea of ‘meltdowns’ in autism. When discussing what causes frustration for children with autism, Expert 1 said “people with autism need time to process information. They process information differently to neurotypical people as they need to gather lots of information before they understand something, they don't create shortcuts and if information comes too rapidly for them, they can find that

distressing". Allowing choice regarding level of difficulty will create an environment where the user can feel comfortable to progress at their own speed, with time to process. This also aligns with my fifth criteria, interchangeable time constraints.

Expert 3 commented that if a user is given a task too difficult for them to manage or comprehend, it could lead to an aggressive, distressed response. The Personal Profile supports this and says that frustration in her child causes them to become very aggressive and in need of time to cool off afterwards.

Regarding meltdowns, Expert 1 offers the definition "a meltdown is where an autistic person is overwhelmed with information. Sometimes they freeze, or they can become agitated and potentially run off". In terms of gamified learning interventions, he states that "if information comes too rapidly for them, they can find that distressing, they cannot understand and in extreme cases can have a meltdown, which is where they become very agitated and distressed". Throughout game design this is something to take into consideration, especially when a child may be given a task outside of their ability, even as a worst-case scenario response.

3. Option to personalise avatar appearance where appropriate in a serious game.

When designing learning activities for children with autism, implementing personalised content in a serious game can increase engagement and immersion and therefore lead to successful outcomes. To quote Tsikinas and Xinogalos (2018), "defining the appearance of the protagonist of the game endorses the sense of uniqueness to the players". Many games designed for children with autism have the main purpose of teaching specific social skills, such as personal hygiene and politeness, as well as more general 'soft skills', such as empathy and compassion. If users can learn these aptitudes from a character to which they can relate, this will make this process more relevant to them. For this reason, it is essential that a full range of characteristics are available, including ethnic characteristics as one would not wish to alienate the user.

<u>Supporting Evidence for Criterion 3.</u>

Expert 1's opinion on a personally adapted avatar within a serious game is that whilst "they may need more time to make a choice and need more information before choosing", it would be very helpful to teach the concept of social stories, in which he specialises.
"Social story is a story which is used for people with autism, it's like a script about some kind of social interaction so they can learn what is appropriate. If the avatar is advising them what to say here, what to do there to apply to real life. That's exactly what a social story is". He expresses support for the use and effectiveness of visual tools, such as an avatar. I will address the concept of Social Stories™ further in the next criterion.

Expert 2 discussed social emotional reciprocity and how children with autism may struggle with such a concept, "reciprocity refers to how the behaviour of one person influences and is influenced by the behaviour of another person" (Social Reciprocity - The Autism Society of Baltimore-Chesapeake (ASBC), 2021). As I have stated before, gamified learning interventions can be deemed as a 'safe place' for children with autism, where they hold no social responsibilities and can be comfortable. Because of this, an avatar can effectively demonstrate some ideal behaviours in a secure setting with no judgement.

Expert 3 supports the idea of a personalised avatar due to the control aspect within serious games, "something that isn't them, but it is and that they can learn from".

4. Inclusion of a narrative arc where appropriate in a serious game.

In a serious game, the purpose of a story narrative where it exists is to scaffold learning of a direct educational goal (Lu et al. 2012.) If the educational goals are fully integrated into the narrative, then this provides a strong motivation to the learner to continue with the game. Children with autism will respond well and engage more with narrative content as it gives a meaningful structure to the learning content.

Social Stories™ are tools that are increasingly used by professionals working with children or adults with autism. To quote Gray (1994), the inventor of Social Stories™, "the goal of a social story is to share accurate social information in a reassuring manner that is easily understood by its audience. A social story describes a situation, skill, or concept in terms of relevant social cues, perspectives and common responses in a specifically defined style and format".

It would be an interesting idea to apply the principles of social stories into the narrative of a serious game. For example, the user will not be able to progress to the next level until having said "thank you." or "please." or the character will not be able to leave base until having brushed their teeth in the morning.

Supporting Evidence for Criterion 4.

When asked about intertwining meaning and context within learning, Expert 1 supported this stating "they lack what is called theory of mind, which is the ability to assume what another person is thinking. Autistic people are very good with literal or factual things, but not so good at theory of mind". This is also where the concept of Social Stories should be implemented, as through a narrative correct social response can be demonstrated in gaming.

The Personal Profile stated that they found that their child needed to know the reason why they are carrying out a task and can get frustrated if they don't understand what the reasoning behind it is. Expert 3 also offered a personal account regarding someone that they work with: "They will ask a lot of questions unless there's a reason why they're going to be doing this, such as why am I doing it? What's the point? If there is no point, then they can get quite annoyed, saying why have you asked me to do this?".

Therefore, a narrative arc which a child can refer to throughout the game and describes the purpose of the game and the target that they are aiming for is a useful tool to implement.

5) Lack of time constraints, or modified time limits within the serious game.

Much gameplay is based on completing tasks within a strict time frame or against other variables or perceived hazards. Certain tasks may be difficult for children with autism; however, it may be important that they are asked to carry out these tasks as they teach important skills. "Children with autism often exhibit significant language delays and extremely disruptive behaviours when confronted with task situations or other interactions in which they would rather not partake" (Carter, 2001, pp. 1).
Due to the heightened stress response to these tasks, it is important that children with autism are given as much time as they need to formulate a response and are not placed under arbitrary time constraints.
Time constraints introduced by perceived hazards, such as having to complete a task before a meteoroid hits, may be particularly distressing for children with autism as they struggle to focus on the task at the same time as monitoring the perceived hazard. Mackinlay et al (2006) "found that children with autism were less efficient in planning and task switching and attempted fewer tasks than healthy controls, indicating a specific impairment in multitasking in children with autism" (Yang et al., 2017).

Whilst some researchers suggest that an assigned time limit can help to structure a challenge, this must be implemented in a way which is perceived as non-threatening. To refer back to the concept of adaptive progression which is outlined in criterion 2), it may be appropriate for the game to set adaptive time limits based on in-game play (Grossberg and Kishnan, 2018).

Supporting Evidence for Criterion 5.

Expert 1's most well-established point is to give children with autism more time to process information. "People with autism need time to process information. They process information differently to neurotypical people. They need to gather lots of information before they understand something they don't create shortcuts and if information comes too rapidly for them they can find that distressing". This is an obvious supporting quote for removing, or modifying time restrictions.

The Personal Profile says that if their child feels rushed through a task then once again they will feel frustrated and not want to continue. Especially if they don't fully understand what they are meant to do in the task yet.

6) Implement recurring feedback and positive reinforcement within the game.

A feature of serious games that increases involvement and immersion for children with autism is the use of feedback to encourage users and promote engagement (Christinaki et al. 2014; Everhart et al. 2011; Freina et al. 2016). According to Kiili (2005), "the use of immediate and appropriate feedback in a game-based learning experience can lead to the state of total immersion and engagement, defined as flow." This is an important concept in the design of a serious game for children with autism as it decreases both boredom and distractions. (Tsikinas and Xinogalos, 2020)

Positive feedback and rewards are clearly motivating for all users, especially those with autism, and their use could link effectively with the concept of social stories™ as outlined earlier. For example, in a game to promote healthy eating the user would receive positive comments, such as "Good Choice!" and "That's really healthy!" as well as healthy point boosters. This should be positively received as Groen et al (2008) found that children with autism showed very high anticipation towards receiving positive feedback throughout a given task (Zamani, Fatemi and Karimi, 2015).

The majority of games are by nature goal-directed, however research (Grolnick et al., 1996) suggests that other methods that could be applied to children with autism include comfort strategies which aim to soothe or reassure the user rather than reward them (Gulsrud, Jahromi and Kasari, 2009).

In addition to this, negative feedback and consequences can have a seriously detrimental effect on the user. Greenberg et al. (2006) and Baker et al. (2011b) showed that caregiver criticism can lead to behavioural problems in children with autism, and therefore it would be undesirable to implement this into game design (Baker, Fenning, Howland and Huynh, 2018). In many commercial games, characters "die". It is clear that in any serious game aimed at children with autism that this is wholly inappropriate, especially if the character has been made to resemble them and could cause a serious stress reaction such as a shutdown.
The underlying principle should always be that good choices will be rewarded and commented upon, rather than bad choices being punished or criticized.

Supporting Evidence for Criterion 6.

The Personal Profile discussed the importance of their child knowing that when learning they are improving. "With games, they like to know that they're getting better so saying "well done, you're getting there" and "you got this" really helps".

Expert 3, who also previously in the interview put a lot of emphasis on the idea of inclusivity in games, for example techniques that will not single out any child but will make serious games desirable for everyone. This is of course the main goal of my project, and therefore the use of reassuring language should be applied in games as all children respond positively to it.

7) Implementation of frequent, clear instructions within the game.

Language skills and acquisition both in terms of using and recognising language are often delayed, or under-developed, in children with autism. To quote from Tager-Flusberg, H., (1994), this can "range from the almost complete absence of functional communication to adequate linguistic knowledge". To reflect this spectrum of autistic needs, the use of instructions in serious games should range from pictorial instructions for those with no functional understanding of linguistic communication, to simple and unambiguous instructions for those with adequate but impaired communication skills. As children with autism often respond better to uncluttered screens, it will be useful for instructions to appear at the beginning of the task and be retrievable at any time during the task if necessary, to reduce confusion, anxiety and stress.
Where possible, it would be advantageous for serious games to ensure a consistency in language across various platforms. It could be confusing for a child with autism to be instructed to complete similar tasks but using vastly different language.

Supporting Evidence for Criterion 7.

When discussing common communication barriers for children with autism, Expert 1 describes one of the most prominent difficulties, which also can appear frequently in gamified learning interventions, "not understanding language that isn't literal like metaphors, they won't understand inferences. That's the most important thing in communications".
To also aid a child with autism, we discussed how the layout of a serious game can be most facilitating. Expert 1's suggestion was that "images were clear and not cluttered. Graphics would be clear and not mixed" which I also inferred in my discussion.

The Personal Profile thought that this modification for serious games was especially significant, as their child needs instructions laid out very clearly in order to fully comprehend the task, and they'll need to have constant access to instructions as well. They also discussed how their child reacted poorly to too much information and tasks on a display screen to complete at once.
Expert 2 discussed the difference in social communication for a child with autism within a learning environment; "social communication can be different in autism. For example a teacher that's using ambiguous language should instead be direct and clear in what they want".

Expert 2 also says that it is important to explain a situation in a way that is communicative and manageable and supports people with autism.

8) Include a selection of guidance, such as walkthroughs, hints, practice rounds and commentaries.

The implementation of specific guidances are necessary to ensure that the user does not get stuck on a level, task, or question. This is widely considered good practice for games generally, but children with autism may be more likely than their peers to experience intense frustration and express it through tantrums and meltdowns if these adjustments are not provided (France, 2021). If the user cannot get past something they may feel frustrated and therefore willingness to continue may decline, due to difficulties within emotional regulations (Jahromi, Meek and Ober-Reynolds, 2012). In the worst-case scenario, children with autism can be pushed into a shutdown if they feel that they cannot find a solution.

To alleviate these problems within serious games, there are various methods that can be applied within the game design or as separate bolt-ons. Walkthroughs can be used, which are a guided demonstration of how to successfully complete the game. This is a type of support mechanism, so that the user knows that they will be able to find a solution to a given problem and avoids the feelings of panic that may arise from not being able to do so.
Hints can also be helpful, especially if used in an adaptive progressive way. For example, once the user has attempted a level or task more than three times but has failed, a message can appear in reassuring language along the lines of: "You're doing great so far! Why don't you try this?". This will once again encourage the user to continue and provides a supportive framework.

Due to social cognitive problems, children with autism may experience a slightly delayed timed response (Sears et al, 1994; Szelag et al., 2004). Therefore, an offer to complete a practice round not only offers valuable instruction, but also a time buffer to allow the child with autism time to process the information needed to complete the game, and to adapt their mindset to the game environment.

The idea of commentary can also be implemented to offer more specific details such as background information and reasonings for the task. Children with autism process information in different ways, which may make them disinclined to complete a task unless they are implicitly aware of the reason for completing the given task, as they may struggle to think intuitively (Dundon and Scott, 2019).

Another example of a different processing technique used by children with autism which may not be considered by thus-far gamified technology is 'bottom-up' abstract thinking. My evidence that this has not been previously considered consists of a key word search in Google Scholar for both 'Bottom-Up Thinking' and 'Serious Games' which gave no results. 'Bottom-up' thinking is the process of compiling a bigger picture through specific small details. The purpose of commentary would be to explain the small details and provide links to the bigger picture.
An account from Temple Grandin (2009) states "All my thinking is bottom- up instead of top-down. I find lots of little details and put them together to form concepts and theories. Most people must have a theory first, and then they try to make the data conform to it. My mind works the opposite way. I put lots of little pieces of data together to form a new theory." (Grandin, 2009)

<u>Supporting Evidence for Criterion 8.</u>

For Expert 1, this was the topic they thought deserved the most attention when referring to reasonable adjustments in gamified learning interventions. As guidance should be offered to users in case a level is too difficult or they get stuck on a certain task, he said: "The thing is they might not get past the first level but you need to make a reasonable adjustment to allow them the opportunity to. I noticed that you referred to reasonable adjustments, this is very important when working with people with autism. It doesn't mean they always have to be right or get what they want, but you need to demonstrate that you have taken into account their condition otherwise it's not fair and that's what a reasonable adjustment is".
Whilst a child with autism at first may not understand a task, Expert 1 provides a very straight-forward definition of the internal process 'Bottom Up Thinking': "Sometimes it seems like they don't understand, but once they've put the information together they understand very well, maybe even better than a neurotypical person. It just takes them longer to get there, they can process a lot of information but just need longer". This supports my criteria points of removing time constraints, choice of level of difficulty, recurring feedback and offering guidance.

Expert 3 emphasises the importance of guidance throughout gamified learning inventions as if a child with autism feels stuck or cannot get past a level, it will cause a strong feeling of frustration which once again could lead to a meltdown.

The Personal Profile says that when their child feels stuck on a level or task, it will make them lose interest and not want to try again, they say that their child has a “ridiculous fear of failing "which they feel a lot of children with autism may have too, therefore this should be taken into consideration within gamified learning interventions and certain guidance can help to aid this. They also strongly agreed that a child should have constant access to the instructions of the game throughout, saying that they thought this would really help their child.

9) Implement warnings about upcoming changes and transitions.

Extensive research has proven that children and adults with autism can respond negatively to any change in environment, especially when it is unexpected. “It may thus be supposed that any change, even nonsignificant, occurring in the environment of the autistic child may lead to attention switching and, as a consequence, to distractibility and distress” (Gomot et al., 2002). To mitigate against these problems, there are various techniques that can be used within the gaming environment. For example, a schedule or timeline can be available throughout the game so that the user knows what to expect. As routine is an incredibly comforting tool for children and adults, to depict a schedule within a game could offer an aspect of reassurance. Also, a countdown timer can appear before the gaming environment is about to change. Where there is a transition within the sensory environment, rather than a sudden jumpcut, a more gradual, faded change is preferred.

Supporting Evidence for Criterion 9.

Expert 1 confirmed my research regarding how children with autism cope with a change to environment, they stated that “they can respond to unfamiliar situations by freezing, not responding, or becoming confused”. A simple application of a small warning message would be a helpful suggestion for gamified learning interventions.

The Personal Profile mentioned that their child did not respond well to sudden and unexpected changes to their environment, especially if they do not understand why the change is occurring. Expert 3 says that it is important for a child to know that the change is going to happen and why: “Knowing this change is going to happen, if not it is going to cause a reaction and be a trigger, this depends on the child. So, this sort of comes back to my frustration”.

Regarding predictability in gamified learning interventions and changes in environment, Expert 2 mentions how people with autism have an intolerance to uncertainty, stating that “There are all sorts of psychophysical ideas around predictability of the environment like in computational modelling, and predictive validity. People with autism find it difficult to predict compared to neurotypical people so if you give them a structure where predictability is inherent, they're going to feel more comfortable to be effective”. The Personal Profile supported this comment by emphasising the importance of routine and a foreseeable structure for their child. Taking these accounts into consideration, a schedule or timeline being available throughout the game so that the user knows what to expect should be very strongly recommended.

10) Use of an explicit and consistent reward system throughout the serious game.

Children with autism respond positively to rewards, especially when they feel that they are fairly and consistently allocated. Parents and other caregivers frequently find that reward systems, such as sticker charts, where children can accumulate visible achievements are extremely effective at reinforcing positive behaviour and motivation. The same principle can be easily transferred into gamified learning interventions. Humphry (2011) states that gamified learning interventions must reward what is considered ‘appropriate behaviour’ to maintain the interest of the user and that a reward system should be considered crucial for any intervention for children with autism.

Humphry (2011) also found that children with autism "displayed the highest level of motivation, focus and accuracy when their favourite reward type was presented." (Constantin et al., 2017)

For this type of system to be most effective, the game needs to be broken down into a series of short, manageable tasks or levels, each with a reward achieved at the end. The reward should be cumulative throughout the game, and if possible, through a series of games. From the point of view of the child with autism, it is important that this system is not seen as punitive, and so the rewards tally should only increase, and rewards should not be removed from the player. Solomon et al (2015) found that "individuals with autism spectrum disorders exhibit learning deficits reflecting impaired ability to develop an effective reward-based working memory to guide stimulus selection. Instead, they continue to rely on trial-by-trial feedback processing to support learning". This supports the theory that rewards should be placed at the end of each task, rather than at the end of the game, or game stage. Rewards do not need to be explicit in terms of points but could also be a reward that describes the user's accomplishments. For example, a table or an 'award board', which illustrates which elements of the task were completed well.

Supporting Evidence for Criterion 10.

Expert 1 agrees that a reward system would be an effective tool to promote learning in serious games: "Because they would know they have achieved something and they can see they have a reward, that could be helpful because they would understand what was happening". Once again referring to the idea of inclusivity, Expert 3 mentions how all children, neurotypical or not, appreciate rewards in serious games, therefore this should definitely be included.

In order for a reward system to be maintained, I mentioned that it is essential that a serious game is broken down into manageable tasks. The Personal Profile said that for their child, it is very important that only so much information is presented to their child at a time, if not they will become overwhelmed and maybe have a meltdown. Expert 3 also commented on the importance of small chunks of information being presented at a time.

Challenges Theory

The points below can be interpreted as opposing my theories. As not all the criteria had opposing points, I have listed these together in one section and referenced which criteria they refer to where appropriate.

When discussing their experience with people with autism, Expert 1 stated that "people with autism don't really think about other people's opinions so praise might not really affect them", and Expert 2 agreed that reassuring language and praise may not have much impact. This therefore disagrees with Groen et al's (2008) supposition that children with autism respond eagerly to positive feedback, and with my 6th criteria; Implement recurring feedback and positive reinforcement within the game. However, I believe that this also supports my point that children with autism respond well in the digital environment as the praise from a computer game exists in an 'emotional vacuum' that may render it more valid to children with autism than if it comes directly from a person.

As Expert 1 had discussed earlier, people with autism lack an ability called 'Theory of Mind', meaning that to be able to assume or intuitively know what someone is thinking is particularly difficult. This process is unknowingly essential to social interactions and communications, as it also helps to gain perception of what others think of you, and "human cooperation and moral reasoning" (Senju, 2011). Research suggests that this may be why people with autism seem disinterested in others, or that they do not care for their opinion. This could contribute to Expert 1's

mindset, which had less to do with the idea and implementation of praise in games, but rather the 'black and white' mindset of an adult with autism.

It is also important to consider that Expert 1's research is regarding adults with autism and real-life interactions, not children on whom I focus. For children with autism, it is still relevant that they struggle to create social connections and participations (Hale and Tager-Flusberg, 2005), however portraying disinterest and evoking negative social connotations is much easier for an adult than a child. Therefore, Expert 1's earlier quote "people with autism don't really think about other people's opinions so praise might not really affect them", is more relevant to an adult with autism. This is understandable as their work in the field of autism more frequently revolves around adults rather than children and is also suggested by their language as they said "In my experience" before further dialogue
.
From what I have gathered through my research and as expressed in my 6th criteria, children with autism do respond well to positive feedback, as it is a comfort strategy which is often administered in learning. It is important to note that, as stated throughout my interview with Expert 3, inclusivity is an essential idea throughout this criterion. All children need some standard of reassuring language while learning.

Expert 1 also held the opinion that people with autism respond well to negative feedback, stating that "you don't need to beat around the bush". This is a helpful insight and although once again it may be more relevant to adults with autism rather than children, to be able to accept and respond well to criticism is an important aspect for serious games. However, rather than negative language I think feedback should be more constructive.
Therefore, from this interaction with Expert 1 I changed 'Absence of Negative feedback' to 'Absence of Negative Language in feedback'.

<u>Unreliable</u>

The points below can be interpreted as contradictory or showing uncertainty. As not all the criteria had unreliable points, I have listed these together in one section and referenced which criteria they refer to where appropriate.

Some questions I asked Expert 1 regarding my criteria were met with aspects of uncertainty. This was deciphered by the use of language such as 'it might' and 'I suppose so'. Whilst in many cases they did come to a supporting, positive conclusion I think first initial opinions of a proposal are worth considering.

For example, when asked about reward systems within gamified learning interventions for children with autism, they said that "I suppose they might like a reward system because they would know they have achieved something and they can see they have a reward, that could be helpful because they would understand what was happening". This is not their area of expertise which could explain the element of ambivalence.

Expert 1 offered an interesting personal account from their work with people with autism, stating that "One of the problems is if you try to tell a person with autism things too quickly they may tell you they understand even if they don't, sometimes even just as a way to get you to stop talking". Whilst I have found it difficult to find other supporting research on this matter, it is still a relevant description of their experience, but less so in game design. If I was able to find further research I would like to be able to measure the effect of the implementation of examples such as a button which appears after instructions have been given which says "okay?", which they would have to press before beginning the game.
When asking Expert 2 about frustration and its impact on children with autism, they said that this was something about which they had seen very little, or no, research. "I don't know how many people have researched issues around frustration, so I think there are two issues. One is the idea if

autistic people feel the same frustration or not, and the second would be the same. And the second question would be how they would respond to it."

Insight

Through my interviews with the experts, they suggested ideas for my criteria. These are listed below:

When asked about time constraints in games, Expert 1 said that "they need to have more time to process, not be rushed and sometimes need time alone to process. In a gaming situation they will need to be able to take breaks". Being able to pause serious games is extremely important for children with autism in case they feel overwhelmed, and this was not something I had yet considered. Therefore, I added this suggestion to my criteria under the sub-topic 'Time Constraints'.

Expert 2 recommended that open ended questions should be avoided in gamified learning interventions, as adults and children find direct and specific questions much more manageable. This is illustrated in Ganz and Flores's investigation (2008) on the "effects of a Direct Instruction (DI) language program implemented with elementary students with ASD".

Expert 3 discussed the term 'executive functioning challenges'. Executive functions (EFs) are mental control processes that enable self-control necessary for the attainment of a future goal (Verté et al., 2006). Expert 3 said that in terms of gamified learning interventions, "asking a child to organise something, asking a child to plan something or expecting them to hold information with memory challenges, this can really frustrate them or could sort of get them to kick off basically." This could be implemented in serious games, possibly by reminding the user throughout the game of their target or goal.

The Personal Profile suggested that "when the user has finished a topic you could give the children the choice to go over it again, to see if they can beat their own score". For their child they thought it would be extremely helpful as it is an evident validation that they are improving.

From these insights, I was able to create my definitive checklist.

Checklist

From the criteria listed and explained previously, these are the templates for my checklist and a checklist derived from Yusoff's scale, which I will use to evaluate existing games.

Table 3 Example Checklist for my Criteria to establish appropriateness of a Serious Game for children with autism, which throughout the game evaluation I will refer to as 'First Criteria'.

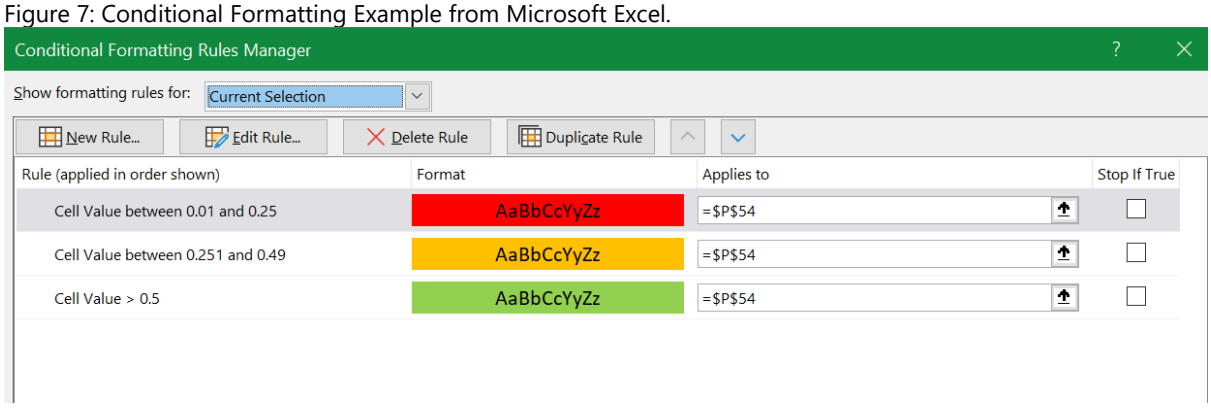
Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Example			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	Y
Warning of loud noises	N	Y	N	N
Option to turn off loud noises	N	Y	N	N
Remove background noise	Y	N	N	N
Speech bubbles opt in	N	N	N	Y
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	N	Y
Warning of strobe lights	N	N	Y	N
Option to turn off strobe lights	Y	N	N	Y
No bright lights	Y	N	N	N
Options to change colour palettte	N	Y	N	N
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	Y	N
Select difficulty level	Y	N	N	N
Visual Personalisation				
Definable appearance	N	Y	N	N
Full range of characteristics available	N	Y	N	N
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	N
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	Y	N	N
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	Y	N	N	N
Absence of character or avatar 'death'	N	N	N	Y
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	Y	N	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	N	Y	N
Hint	Y	N	N	N
Commentary	Y	N	N	N
Practice Round	Y	N	N	N
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	Y	N	N
Rewards				
Cumulative rewards (rewards not removed)	Y	N	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	70%			

Table 4 Example of Yusoff's Criteria to define a Serious Game, which throughout the games evaluation I will refer to as 'Second Criteria'.

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory		Example			
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	Y	N	N	N
Practice and Drill	Taught skill is repeated in the game	N	N	N	Y
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	N	Y	N	N
Linearity	Increasing level of difficulty	N	N	N	Y
Attention Span	To keep concentration high, game has short duration per level	N	N	Y	N
Transfer of learned skills	Application of skills in different environments	N	N	N	Y
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	N	Y	N	N
Learner Control	Choices offered in game, for example duration	N	Y	N	N
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	Y	N	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	N	Y	N	N
Criteria satisfaction		39%			

Once I had designed the checklist, I was able to use it to evaluate each game. I calculated the overall percentage by using a Count If function within each column. For the Fully Implemented column I then multiplied this by 2 in accordance with my points system. The formula therefore was =COUNTIF(P3:P51,"Y")*2. For the partially implemented column I used the same formula but only accorded one point. As the Not relevant column did not count in the final tally there were no points allocated to this column. For the Not Implemented I allocated -1 points and the formula was =COUNTIF(S3:S51,"Y")*-1. I then added up the totals for the Fully implemented, Partially implemented and Not Implemented columns. To derive the overall percentage I divided this number by 78 (the maximum score for the 39 criteria) minus the amount in the Not Relevant column. I then used conditional formatting to colour the percentage Green if it was above 40%, Orange for between 20 and 39.99% and Red if it was below 20%. I repeated the same process for Yusoff's criteria, except the maximum score was 24 and percentages were based on this.

Figure 7: Conditional Formatting Example from Microsoft Excel.



In order to extract further useful data from the spreadsheet, I then calculated the average percentage score for each criteria across all ten games using COUNTIF formulae and then multiplying by ten to get a percentage. Finally, I calculated the average percent for each group of criteria as demonstrated in the table below.

Table 5: Average Percentages for Criteria Example from Microsoft Excel

Design Criteria for Games for children with autism	Overall Fully Implemented %	Overall Partially Implemented %
Environmental Modifications	**38**	**13**
Mute available	100	0
Volume control	90	10
Warning of loud noises	10	40
Option to turn off loud noises	10	30
Remove background noise	40	20
Speech bubbles opt in	70	0
Warning of high pitched noises	0	0
Option to turn off high pitched noises	0	0
Warning of strobe lights	0	0
Option to turn off strobe lights	20	0
No bright lights	50	40
Options to change colour palettte	20	20
Option to change brightness	90	10
Difficulty Levels	**35**	**10**
Adaptive Progression	30	10
Select difficulty level	40	10
Visual Personalisation	**20**	**20**
Definable appearance	20	20
Full range of characteristics available	20	20
Narrative Arc	**75**	**10**
Narrative element present	70	20
Social element present	80	0
Time Constraints	**63**	**7**
Allow user to pause game	100	0
Removal of time constraints	80	0
Modification of time constraints	10	20
Positive Reinforcement	**47**	**33**
Immediate and appropriate feedback	60	40
Absence of negative language in feedback	50	50
Absence of character or avatar 'death'	30	10
Clarity of Instruction	**73**	**18**
Pictorial instructions	80	10
Instructions are simple and unambiguous	50	40
Uncluttered Screen	60	20
Instructions retrievable throughout the game	100	0
Guidance Available	**54**	**22**
Walkthrough	20	30
Hint	50	20
Commentary	90	10
Practice Round	50	10
Reassuring Language	60	40
Warning Messages	**43**	**20**
Time-lines Schedules	60	40
Avoid jumpcut	70	10
Coutdown timer to significant change	0	10
Rewards	**55**	**25**
Cumulative rewards (rewards not removed)	50	40
Game broken down into manageable tasks/levels	60	10

Games Evaluation

Firstly, as an example of the potential effectiveness of my criteria, I will be monitoring the game 'Prism', which I discussed in my first reasonable adjustment modification. Prism was developed by Students from Carnegie Mellon University's Entertainment Technology Center specifically for children with autism, as a serious game which can help children learn how to correctly respond to social and sensory stimuli.

Table 6 First Criteria:

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Prism			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	Y	N	N	N
Option to turn off loud noises	Y	N	N	N
Remove background noise	N	N	N	Y
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	Y	N	N	N
Option to turn off high pitched noises	Y	N	N	N
Warning of strobe lights	N	N	Y	N
Option to turn off strobe lights	N	N	Y	N
No bright lights	N	N	N	Y
Options to change colour palettte	N	Y	Y	N
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	Y	N
Select difficulty level	N	N	Y	N
Visual Personalisation				
Definable appearance	N	Y	N	N
Full range of characteristics available	N	N	N	Y
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	N
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	N	Y	N
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	Y	N	N	N
Absence of character or avatar 'death'	Y	N	N	N
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	Y	N	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	N	N	Y
Hint	Y	N	N	N
Commentary	Y	N	N	N
Practice Round	N	N	N	Y
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	N	Y	N
Rewards				
Cumulative rewards (rewards not removed)	Y	N	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	69%			

Overall Percentage on First Criteria = 69%, which suggests satisfactory suitability for children with autism within the game's design.

Table 7 Second Criteria:

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory		Prism			
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	N	Y	N	N
Practice and Drill	Taught skill is repeated in the game	Y	N	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	Y	N	N	N
Linearity	Increasing level of difficulty	N	N	Y	N
Attention Span	To keep concentration high, game has short duration per level	Y	N	N	N
Transfer of learned skills	Application of skills in different environments	N	Y	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	Y	N	N	N
Learner Control	Choices offered in game, for example duration	N	N	N	Y
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	N	Y	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	N	Y	N	N
Criteria satisfaction		65%			

Overall Percentage on Second Criteria = 65%, conveying satisfactory implementation of serious game designs.

I used the same process for the ten games that I have chosen to evaluate using my checklist (First Criteria) and Yusoff's checklist (Second Criteria). This gave the following results:

Table 8 Summary of Results

	First Criteria	Second Criteria
Name of Game	% Score	% Score
Chill Panda	64%	65%
DragonBox Element	57%	70%
Dream Hospital	17%	30%
Escape The Pacific	29%	29%
Fate of the World	39%	58%
LightBot	71%	70%
Minecraft	70%	39%
Nanobot's Revenge	69%	58%
SimCity 4	60%	74%
Whyville	39%	63%

This summarises the percentage score that each game received using each criterion. The full results are referenced in Appendices 6 and 7.

In summary, I believe that the use of checklists offers two useful pieces of information: firstly in very broad terms whether a game is suitable or not for children with autism (based on an overall score of 40% or more) and secondly a more nuanced appreciation of which aspects of the game may be deemed to be unsuitable so that the user can make an informed choice about the game as all criteria may not be equally valid in all situations , for instance sometimes a game may simply use for structured 'down time' without an explicit educational goal. Therefore, it may be more correct to say rather than 'unsuitable for children with autism' that the game 'may contain elements unsuitable for children with autism.'

Finally, as the information is presented in spreadsheet format, it will provide quantifiable information such as which elements are most or least satisfactorily addressed by designers so that remedial action can be taken in the future. To present the information in such a way that provides a useful tool for game designers, I have created a decision tree. This acts as a visual guide to follow during the designing process.

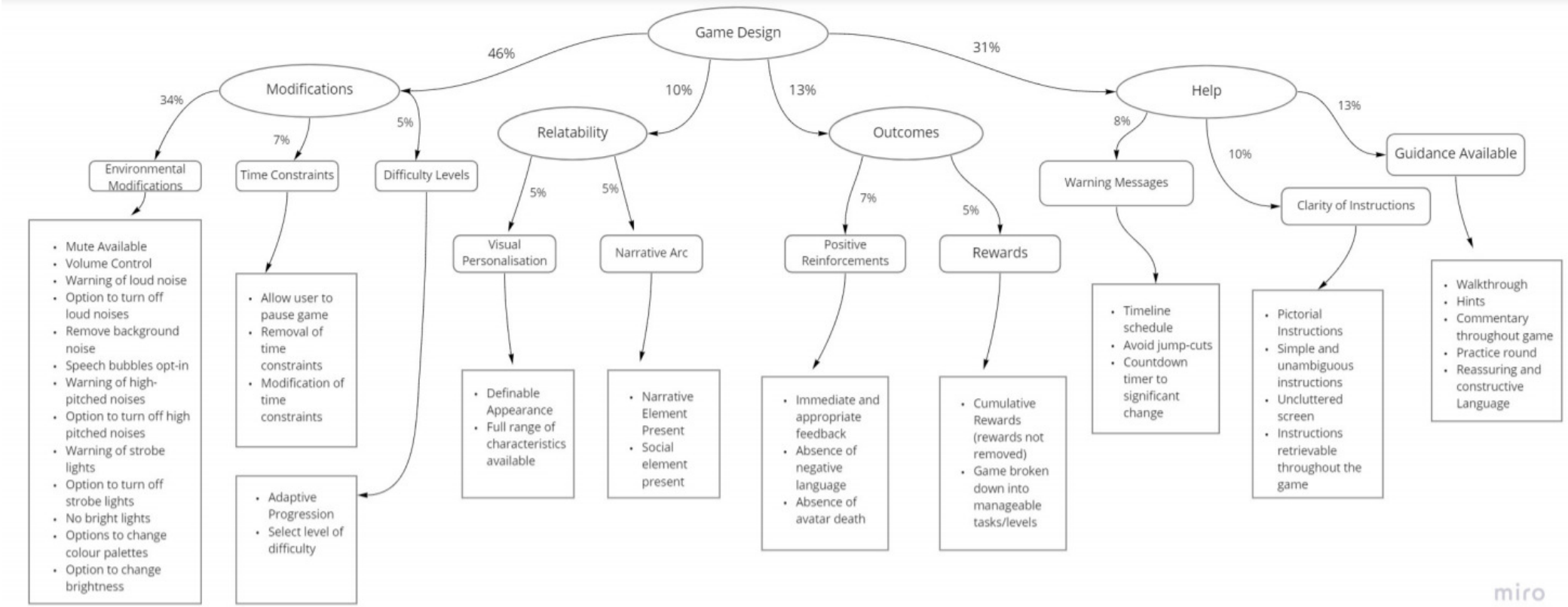
Decision Tree

The top level of the decision tree is the game design itself. This is split into four sub-levels, which are weighted according to the number of criteria within each category in each sub-level. I grouped the categories together to make it more visually comprehensible. I separated this into:

1) Modifications, including Environmental Modifications, Time Constraints and Difficulty Levels.
2) Relatability, including Visual Personalisation and Narrative Arc. These are features that make the experience more personal for the user.
3) Outcomes, including Positive Reinforcements and Rewards. This is labelled Outcomes as they are the results of the user's gameplay.
4) Help, which includes Warning Messages, Clarity of Instructions and Guidance Available.

Finally, each sub-level was split into the original categories from my checklist. The more criteria there were within a category, the greater the percentage weighting of each category. Each criterion is worth 2.6%.

Figure 8 Decision Tree



Limitations

During my research, I found that there were some papers that I could not use as they contained outdated terminology within the autism community. For example, the expressions 'high functioning' and 'low functioning' autism, autism is a spectrum and therefore these terms should be obsolete. The same applies for 'severe', 'moderate' and 'mild' autism. I also found that I actively disregarded papers if the researchers implied that children 'suffer' from autism. Autism is a condition and not a disease, it is fallacious to insinuate otherwise. "What potential does the applied behaviour analysis approach have for the treatment of children and youth with autism?" (Schoen, 2003). This is an example of a paper which includes negative connotations towards autism, as this is a condition that cannot be 'treated', only accommodated for.

Children with autism usually have concurrent conditions, which are conditions that occur simultaneously. Expert 2 listed the most common conditions happening with Autism as: Attention Deficit Hyperactivity Disorder (ADHD), Dyslexia and Dyspraxia. The Personal Profile's child had been diagnosed with Autism and ADHD. Taking this into consideration, my scope for research could have included these conditions also.

In an interview-respondent interaction there is always a high risk of cognitive biases, which can make the interview process less objective. For example, the participants I interviewed could have been presenting answers which they thought would help my research. To prevent this in my data collection, I had to avoid asking leading questions. Instead of asking "do you think this will affect a child's learning experience negatively?", I would ask "how may this affect a child's learning experience?".

The participant recruitment for my thematic analysis was quite simplified as I did not have access to as many professionals on the subject as I would have liked. Expert 1 and 2 are both not specialists in children with autism and whilst they had excellent knowledge on the matter, I understand that there may have been a difference in responses depending on age. The Personal Profile that I used was incredibly useful, as the answers I received were based on direct experience. However, I understand that they are not a professional or specialist and this is only one child's experience. Ideally, I would be able to interview more parents or caregivers who have children with autism, so I could determine if any experiences were a 'one-off'. The Personal Profile's child also has concurrent conditions as they have been diagnosed with both autism and ADHD. ADHD causes "inattention and impulsivity" (NIMH » Attention-Deficit/Hyperactivity Disorder, 2021). Therefore, questions I asked regarding focus may be more relevant only to children with ADHD, not autism.

Only I codified and identified the themes from my data collection, which lessens its validity in comparison with a procedure whereby someone else had to process the transcripts, in which case they may have identified different themes and achieved non-identical results. Also, it is expected that during data collection for a thematic analysis all the interviews take place at the same time to form a panel. However, due to my participant's schedule this was impossible to accomplish. This could have affected my data collection as the experts were meant to have an organic discussion with one-another where they could contribute and add to each other's ideas. In the format that I used; individuals' ideas may not have developed in the way they would have done in a group discussion. In addition to this, in a group discussion we can use agreed terminology and ensure that all members have the same interpretation of these terms. This could affect my data collection as it consists of a series of individual opinions rather than a collective opinion derived from group discussion.

The fact that no game reached higher than 80% from my criteria suggests that the standards I held for these games were unrealistic, and some irrelevant. Because none of the games I

evaluated had an option to change or modify the contrast or saturation, and none of the experts I interviewed mentioned its importance, I removed them from my list of criteria.

Also, some games that are supported by research as being appropriate for children, such as Minecraft™, did not score past 70%. Even the game Prism, which was specifically designed for children with autism, scored only 69%. However, this game was designed by students rather than experts in the field of autism and this may have caused scores to be low in certain areas, although it should be noted that the overall score is well above my threshold of 40%.

Only I have evaluated each game, so once again it is possible that if someone else were to check these games against mine and Yusoff's criteria, they would have gained a different result and overall percentage.

Conclusion

In conclusion, I believe that my research has proved that all the games that I have chosen to evaluate satisfy at least some of the criteria identified by Yusoff and myself and that these games are therefore beneficial to greater or lesser degrees for children with autism. The fact that certain games did not fulfil all the criteria does not necessarily detract from their validity as they may be outside of the remit of the game's purpose. My hope is that the type of criteria that I have designed and the research underpinning this could be used in the future not just for evaluating existing games but to assist in the design and planning for new games, either aimed directly at children with autism or for ensuring that they are inclusive for children with autism. The thematic analysis showed that all the experts and other stakeholders agree on certain themes such as the need for a calming gaming environment and a clearly structured and narrative format to the games along with the ability to complete a game rather than being frustrated by the objectives of the game. Perhaps most importantly, all existing research and the experts that I consulted were unequivocal about the fact that designed correctly, computer games in general and serious games can be an extremely valuable tool in the education, socialisation and the general wellbeing of children with autism. I hope therefore that in a small way my research will contribute to this valuable field by ensuring that parents and educators can be aware of which current games are most accessible and beneficial to children with autism and that designers can be aware of the most effective ways to enable future games to be accessible to these children and enhance their learning environment.

Personal Reflection

My initial intention when I began this project was to create a serious game for children; I then decided that this was too wide a remit and I decided to focus on creating a serious game specifically for children with autism as this was an area of personal interest and I have experience of working with (and playing computer games with) children with autism. Once I began the process of designing the game, I realised that it was impossible without completing extensive and dedicated research into exactly which reasonable adjustments should be incorporated into a serious game to make it appropriate for children with autism.

Once I came across the work of Yusoff and his criteria to define Serious Games, the idea of a checklist fell into place; I felt that his checklist was an extremely valuable tool for evaluating serious games, but for my project it needed to be accompanied by

a second checklist that related specifically to children with autism. The list of criteria that formed my checklist evolved organically throughout my research and some were added as a result of my interviews with experts; for example, the criteria 'Allow the user to pause a game' was not in my original list but was added as a result of my interview with an expert in autism. Similarly, some criteria became unnecessary once it became clear that no games featured these and that they were not as important as I initially assumed. Examples of this included the options to reduce contrast and saturation which were removed from my final checklist.

I am extremely pleased with my final checklist and I believe that is validated by the range of results that each game achieved. No game achieved anywhere near 100% which I believe would have indicated that the criteria were not stringent enough and no game achieved less than 19% which would have indicated that the criteria were too difficult to achieve. One way in which my thinking throughout the project evolved was that I soon came to realise that a very high percentage was not a realistic aim and it was just as important for the game to satisfy the majority of criteria. This was the reason that I reduced the threshold from 50% to 40%. It was equally important for me to see in which areas the various games were most and least satisfactory. This is the reason that I added the average columns to my checklists at the end of the project. From my research, Environmental Modifications in Serious Games emerged as the most important consideration and therefore this had the most criteria and highest weighting in my checklist and decision tree.

One of the main things that I have learned through completing this dissertation is the need to remain flexible in my thinking regarding the outcomes of my project. Whilst I may have had strong ideas at the start of the project regarding the results, these were often challenged during the course of the research and in particular the discussion with the experts. It is important that the final results were decided by the evidence of the research and the experts rather by what I wanted the results to be. An example of this would be the attitude that children with autism have towards rewards that was mentioned by Expert 1. This did not agree with my initial hypothesis but was clearly still a valuable input.

I also found that the comments from my Supervisor were extremely useful in focussing my thoughts. An example of this is that one of my initial remits was to design a checklist that would be appropriate for evaluating serious games whilst trying to create a game myself, however it was suggested that this was too wide a focus and too difficult a task which would dilute my aims, so the concentration was focussed on evaluating a selection of Serious Games. Similarly, my first draft was clumsy and cluttered with each game being evaluated individually, the project came together far more clearly when I introduced a single table to show the overall results for all the games .

Another way in which I was able to adapt was that initially I was going to identify all my own games to evaluate using a series of searchwords. However, as I stated in the text, this proved difficult and so I decided to use a pre-existing list of games provided by Juliette Denny and augmented this with a few games that I had selected myself.

Overall, through my research I only expected to find around 20 criteria, however, the end result was 39 criteria. It was remarkable to discover how many small details that I would never have considered could make all the difference to someone with autism, and I enjoyed the process of personally configurating a reasonable adjustment for each aspect.

References

Connolly, T., Boyle, E., MacArthur, E., Hainey, T. and Boyle, J., 2012. A systematic literature review of empirical evidence on computer games and serious games. Computers & Education, 59(2), pp.661-686.
Abirached, B., Zhang, Y. and Park, J., 2012. Understanding User Needs for Serious Games for Teaching Children with Autism Spectrum Disorders Emotions.
Grossard, C., Grynspan, O., Serret, S., Jouen, A., Bailly, K. and Cohen, D., 2017. Serious games to teach social interactions and emotions to individuals with autism spectrum disorders (ASD). Computers & Education, 113, pp.195-211.
Wang, K., 2014. Noise Control: 11 Tips for Helping your Child with Autism Deal with Noise - Friendship Circle - Special Needs Blog. [online] Friendship Circle -- Special Needs Blog. Available at: <https://www.friendshipcircle.org/blog/2014/05/06/noise-control-11-tips-for-helping-your-child-with-autism-deal-with-noise/> [Accessed 6 April 2021].
Tomchek, S. and Dunn, W., 2007. Sensory Processing in Children With and Without Autism: A Comparative Study Using the Short Sensory Profile. American Journal of Occupational Therapy, 61(2), pp.190-200.
Day, N., 2019. [online] Hes-extraordinary.com. Available at: <https://hes-extraordinary.com/the-auditory-system> [Accessed 6 April 2021].
Bogdashina, O., 2021. Sensory Intolerance in Autism - Integrated Treatment Services. [online] Integrated Treatment Services. Available at: <https://www.integratedtreatmentservices.co.uk/blog/sensory-intolerance-in-autism/#:~:text=For%20many%20autistic%20children%20and,the%20fluorescent%20lights%20are%20on.> [Accessed 31 March 2021].
Chamak, B., Bonniau, B., Jaunay, E. and Cohen, D., 2008. What Can We Learn about Autism from Autistic Persons?. Psychotherapy and Psychosomatics, 77(5), pp.271-279.
Grandin, T., 2006. Thinking in pictures.
Grandgeorge, M. and Masataka, N., 2016. Atypical Color Preference in Children with Autism Spectrum Disorder. Frontiers in Psychology, 7.
Carter, C., 2001. Using Choice with Game Play to Increase Language Skills and Interactive Behaviors in Children with Autism. Journal of Positive Behavior Interventions, 3(3), pp.131-151.
Tager-Flusberg, H., 1994. Understanding other minds: perspectives from autism. Choice Reviews Online, 31(06), pp.31-3492-31-3492.

Grossberg, S. and Kishnan, D., 2018. Neural Dynamics of Autistic Repetitive Behaviors and Fragile X Syndrome: Basal Ganglia Movement Gating and mGluR-Modulated Adaptively Timed Learning. Frontiers in Psychology, 9.

Gomot, M., Giard, M., Adrien, J., Barthelemy, C. and Bruneau, N., 2002. Hypersensitivity to acoustic change in children with autism: Electrophysiological evidence of left frontal cortex dysfunctioning. Psychophysiology, 39(5), pp.577-584.

Constantin, A., Johnson, H., Smith, E., Lengyel, D. and Brosnan, M., 2017. Designing computer-based rewards with and for children with Autism Spectrum Disorder and/or Intellectual Disability. Computers in Human Behavior, 75, pp.404-414.

Grandin, T., 2009. How does visual thinking work in the mind of a person with autism? A personal account. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1522), pp.1437-1442.

Williams, D., 2010. Theory of own mind in autism. Autism, 14(5), pp.474-494.
Yang, T., Xie, W., Chen, C., Altgassen, M., Wang, Y., Cheung, E. and Chan, R., 2017. The development of multitasking in children aged 7–12 years: Evidence from cross-sectional and longitudinal data. Journal of Experimental Child Psychology, 161, pp.63-80.
Jahromi, L., Meek, S. and Ober-Reynolds, S., 2012. Emotion regulation in the context of frustration in children with high functioning autism and their typical peers. Journal of Child Psychology and Psychiatry, 53(12), pp.1250-1258.

Zamani, M., Fatemi, R. and Karimi, S., 2015. Effects of Feedback With Different Frequency on Throwing Skill Learning in Children With Autism Spectrum Disorder Compared to Normal Children. International Journal of School Health, 2(1).
France, G., 2021. Anger, Frustration, And Family Feuding – Dealing With Meltdowns In Autistic Children - Living Autism. [online] Living Autism. Available at: <https://livingautism.com/anger-frustration-family-feuding-dealing-meltdowns-autistic-children/> [Accessed 4 April 2021].
Whyte, E., Smyth, J. and Scherf, K., 2014. Designing Serious Game Interventions for Individuals with Autism. Journal of Autism and Developmental Disorders, 45(12), pp.3820-3831.
Baker, J., Fenning, R., Howland, M. and Huynh, D., 2018. Parental criticism and behavior problems in children with autism spectrum disorder. Autism, 23(5), pp.1249-1261.
Collins, J., 2019. Try Seeing the World through Autistic Eyes. [online] Southwest Health. Available at: <https://www.southwesthealth.org/my-healthy-life/autism/> [Accessed 4 April 2021].
Kulman, R., 2018. Video Games Can Help Children with Autism Function Better - LearningWorks for Kids. [online] LearningWorks for Kids. Available at: <https://learningworksforkids.com/2018/03/video-games-can-help-children-autism-function-better/> [Accessed 4 April 2021].
Wilkinson P. (2016) A Brief History of Serious Games. In: Dörner R., Göbel S., Kickmeier-Rust M., Masuch M., Zweig K. (eds) Entertainment Computing and Serious Games. Lecture Notes in Computer Science, vol 9970. Springer, Cham. https://doi.org/10.1007/978-3-319-46152-6_2
Yusoff, A., 2010. A conceptual framework for serious games and its validation.
Ekaputra, G., Lim, C. and I. Eng, K., 2013. Minecraft: A Game as an Education and Scientific Learning Tool. Education and Curriculum Track,.
Kuhn, J., 2017. Minecraft: Education Edition. CALICO Journal, 35(2), pp.214-223.
Dundon, R. and Scott, C., 2019. Teaching social skills to children with autism using Minecraft.
Denny, J., 2019. The Top 10 Serious Games of All Time. [online] Linkedin.com. Available at: <https://www.linkedin.com/pulse/top-10-serious-games-all-time-juliette-denny> [Accessed 14 April 2021].
Gouws, L., Bradshaw, K. and Wentworth, P., 2013. An evaluation of the educational game Light-Bot. Computational Thinking in Educational Activities,.
Inc, L., 2021. LightBot. [online] Lightbot.com. Available at: <https://lightbot.com/> [Accessed 14 April 2021].

Omidyar, P., 2013. Re-Mission - Hopelab. [online] Hopelab. Available at: <https://hopelab.org/product/re-mission/> [Accessed 14 April 2021].

Waddington, D., 2015. Dewey and Video Games: From Education through Occupations to Education through Simulations. Educational Theory, 65(1), pp.1-20.

Store.steampowered.com. 2013. Fate of the World on Steam. [online] Available at: <https://store.steampowered.com/app/80200/Fate_of_the_World/> [Accessed 14 April 2021].

Galas, C. and Sun, J., 2007. Whyville.

Minnery, J. and Searle, G., 2013. Toying with the City? Using the Computer Game SimCity™4 in Planning Education. Planning Practice & Research, 29(1), pp.41-55.

Hwang, Y. and Kearney, P., 2015. A mindfulness intervention for children with autism spectrum disorder.

Carmichael, S., 2017. DragonBox Elements learning game teaches geometry through puzzles - Classcraft Blog. [online] Resource hub for schools and districts. Available at: <https://www.classcraft.com/blog/geometry-dragonbox-elements/> [Accessed 15 April 2021].

Moyer-Packenham, P., Lommatsch, C., Litster, K., Ashby, J., Bullock, E., Roxburgh, A., Shumway, J., Speed, E., Covington, B., Hartmann, C., Clarke-Midura, J., Skaria, J., Westenskow, A., MacDonald, B., Symanzik, J. and Jordan, K., 2019. How design features in digital math games support learning and mathematics connections. Computers in Human Behavior, 91, pp.316-332.

Mazurek, M. and Engelhardt, C., 2013. Video game use and problem behaviors in boys with autism spectrum disorders. Research in Autism Spectrum Disorders, 7(2), pp.316-324.

Nowell, L., Norris, J., White, D. and Moules, N., 2017. Thematic Analysis. International Journal of Qualitative Methods, 16(1), p.160940691773384.

Jones, C., 2021. Dr Catherine Jones. [online] Cardiff University. Available at: <https://www.cardiff.ac.uk/people/view/1121155-jones-catherine> [Accessed 19 April 2021].

Caulfield, J., 2021. How to Do Thematic Analysis | A Step-by-Step Guide & Examples. [online] Scribbr. Available at: <https://www.scribbr.com/methodology/thematic-analysis/> [Accessed 19 April 2021].

Senju, A., 2011. Spontaneous Theory of Mind and Its Absence in Autism Spectrum Disorders. The Neuroscientist, 18(2), pp.108-113.

Hale, C. and Tager-Flusberg, H., 2005. Social communication in children with autism. Autism, 9(2), pp.157-178.

Verté, S., Geurts, H., Roeyers, H., Oosterlaan, J. and Sergeant, J., 2006. Executive Functioning in Children with an Autism Spectrum Disorder: Can We Differentiate Within the Spectrum?. Journal of Autism and Developmental Disorders, 36(3), pp.351-372.

Baltimoreautismsociety.org. 2021. Social Reciprocity - The Autism Society of Baltimore-Chesapeake (ASBC). [online] Available at: <https://www.baltimoreautismsociety.org/glossary/term/social-reciprocity/#:~:text=Social%20reciprocity%20is%20the%20back,another%20person%20and%20vice%20versa.> [Accessed 1 May 2021].

Schoen, A., 2003. What potential does the applied behavior analysis approach have for the treatment of children and youth with autism?. Journal of Instructional Psychology(Vol. 30, Issue 2),.

Nimh.nih.gov. 2021. NIMH » Attention-Deficit/Hyperactivity Disorder. [online] Available at: <https://www.nimh.nih.gov/health/topics/attention-deficit-hyperactivity-disorder-adhd/#:~:text=Attention%2Ddeficit%2Fhyperactivity%20disorder%20(,interferes%20with%20functioning%20or%20development.> [Accessed 3 May 2021].

Appendices

Appendix 1) Consent Form which all participants have signed:

CONSENT FORM

Title of research project: Establishing reasonable adjustments for creating gamified interventions which are accessible to users with autism and enhance their user experience.

SREC reference and committee: Cardiff University School of Computer Science and Informatics

Name of Chief/Principal Investigator: Daisy Malbon

	Please initial box
I confirm that I have read the information sheet dated 08/02/2021 version 1 for the above research project.	
I confirm that I have understood the information sheet dated 08/02/2021 version 1 the above research project and that I have had the opportunity to ask questions and that these have been answered satisfactorily.	
I understand that my participation is voluntary, and I am free to withdraw at any time without giving a reason and without any adverse consequences.	

I consent to the processing of my personal information (name and profession) for the purposes explained to me. I understand that such information will be held in accordance with all applicable data protection legislation and in strict confidence, unless disclosure is required by law or professional obligation.	
I understand who will access my personal information which has been provided, how the data will be stored and what will happen to the data at the end of the research project.	
I consent to being audio recorded/ video recorded/ having my photograph taken for the purposes of the research project and I understand how it will be used in the research.	
I understand that anonymised excerpts and/or verbatim quotes from my interview may be used as part of the research publication.	
I understand how the findings and results of the research project will be written up and published.	
I agree to take part in this research project.	

Name of participant (print) Date Signature

Daisy Malbon 08/02/2021
Name of person taking consent (print) Date Signature

_Chief Investigator_____
Role of person taking consent
(print)

THANK YOU FOR PARTICIPATING IN OUR RESEARCH

YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP

Appendix 2) Signatures from participants:

a)

Name of participant (print) Date Signature

Sarah Djemaoun. 28/04/2021

Daisy Malbon 08/02/2021
Name of person taking consent (print) Date Signature

b)

Name of participant (print) Date Signature

Daisy Malbon 08/02/2021
Name of person taking consent (print) Date Signature

17th April 2021

c)

Name of participant (print) Date Signature

Catherine Jones 27/4/21

Daisy Malbon 08/02/2021
Name of person taking consent (print) Date Signature

d)

Name of participant (print) Date Signature

Helen Arnold-Richardson
27/04/2021

Daisy Malbon 08/02/2021
Name of person taking consent (print) Date Signature

Appendix 3) Information Sheet also provided to participants:

Researcher: Daisy Malbon
Professional Email: malbonde@cardiff.ac.uk
Supervisor Email: finnegand@cardiff.ac.uk
Research and Ethics Committee Email: comsc-ethics@cardiff.ac.uk

PARTICIPANT INFORMATION SHEET

Name of Research Project: Establishing reasonable adjustments for creating gamified interventions which are accessible to users with autism and enhance their user experience.

You are being invited to take part in a research project. Before you decide whether or not to take part, it is important for you to understand why the research is being undertaken and what it will involve. Please take time to read the following information carefully and discuss it with others, if you wish.

Thank you for reading this.

1. **What is the purpose of this research project?**

By evaluating pre-existing gamified tools, I will assess how suitable their features are for children with autism and then suggest a set of guidelines and recommendations which I think future applications need to implement.

2. **Why have I been invited to take part?**

You have been invited because you have a professional understanding and speciality in the research area of autism and therefore are an ideal participant for me to interview.

3. **Do I have to take part?**

No, your participation in this research project is entirely voluntary and it is up to you to decide whether or not to take part. If you decide to take part, we will discuss the research project with you [and ask you

to sign a consent form]. If you decide not to take part, you do not have to explain your reasons and it will not affect your legal rights.

You are free to withdraw your consent to participate in the research project at any time, without giving a reason, even after signing the consent form.

4. **What will taking part involve?**

This research project will involve an interview process with myself and will be regarding your opinions on a set of reasonable adjustments for virtual serious games. The interview will be recorded and will be approximately 20-25 minutes long. The interview will be conducted virtually through Zoom.

5. **Will I be paid for taking part?**

No. You should understand that any data you give will be as a gift and you will not benefit financially in the future should this research project lead to the development of a new method within the process of gamification.

6. **What are the possible benefits of taking part?**

There will be no direct advantages or benefits to you from taking part, but your contribution will help us understand how effectively gamified interventions consider users with autism and what can be improved.

7. **What are the possible risks of taking part?**

There are no risks of potential psychological or physical harm to participants from this experiment.

8. **Will my taking part in this research project be kept confidential?**

Any personal information you provide will be managed in accordance with data protection legislation. However, you will be mentioned by name in my Final Project unless you choose to remain anonymous.

9. **What will happen to my Personal Data?**

In regard to personal data, only your name will be available to the public. Cardiff University is the Data Controller and is committed to respecting and protecting your personal data in accordance with your expectations and Data Protection legislation. Further information about Data Protection, including:

- your rights
- the legal basis under which Cardiff University processes your personal data for research
- Cardiff University's Data Protection Policy
- how to contact the Cardiff University Data Protection Officer
- how to contact the Information Commissioner's Office

may be found at https://www.cardiff.ac.uk/public-information/policies-and-procedures/data-protection

Cardiff University will need to share your data with Dr Daniel Finnegan for the purposes of this research project.

I will be processing this data from the beginning of March to the beginning of May. After this time, the research team will anonymise all the personal data it has collected from, or about, you in connection with this research project, except for your consent form. Your consent form will be retained until June and may be accessed by members of the research team and, where necessary, by members of the University's governance and audit teams or by regulatory authorities.

If you choose to withdraw from the research project please note that it will not be possible to withdraw any anonymised data that has already been published.

10. **What happens to the data at the end of the research project?**

The data will be made publicly available and shared within the University and potentially outside of the University. I will not be conducting any further research, but others may as a result of the data being made available.

11. **What will happen to the results of the research project?**

The results are likely to be published by May 2021. It is our intention to publish the results of this research project in academic journals and present findings at conferences. There is an intention to use verbatim quotes from your participation.

12. **What if there is a problem?**

Should you wish to raise a complaint, please contact me using the details at the top of this document and below. Participants should be informed that, if they feel their complaint has not been handled to their satisfaction, they may contact my supervisor or the Chair of the School Research Ethics Committee (their details are also at the top of this document and below.)

If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence, you may have grounds for legal action, but you may have to pay for it.

Professional Email: malbonde@cardiff.ac.uk
Supervisor Email: finnegand@cardiff.ac.uk
Research and Ethics Committee Email: comsc-ethics@cardiff.ac.uk

13. **Who is organising and funding this research project?**

The research is organised by Daisy Malbon, School of Computer Science and Informatics in Cardiff University.

14. **Who has reviewed this research project?**

This research project has been reviewed and given a favourable opinion by the Cardiff University School Research Ethics Committee.

15. **Further information and contact details**

Should you have any questions relating to this research project, you may contact me using the details at the top of this document.

Thank you for considering to take part in this research project. If you decide to participate, you will be given a copy of the Participant Information Sheet and a signed consent form to keep for your records.

Appendix 4) Background Information given to participants:

Interviewee Background Knowledge.
Gamified learning interventions, also called serious games, are engaging virtual environments or simulations which feature an educational purpose and design. In academic settings serious games have become a commonly used learning tool due to their entertainment feature to which children respond well. I am researching how to make appropriate reasonable adjustments for children with autism in gamified learning intervention design.

Criteria of reasonable adjustments for creating gamified learning interventions:

1. **Option to modify the sensory environment within a virtual serious game.**
2. **Option to choose level of difficulty within the gamified learning intervention.**
3. **Option to personalise avatar appearance where appropriate in a serious game.**
4. **Inclusion of a narrative arc where appropriate in a serious game.**
5. **Lack of time constraints, or modified time limits within the serious game.**
6. **Implement recurring feedback and positive reinforcement within the game.**
7. **Implementation of frequent, clear instructions within the game.**
8. **Include a selection of guidance, such as walkthroughs, hints, practice rounds and commentaries.**

9. Implement warnings about upcoming changes and transitions.
10. Use of an explicit and consistent reward system throughout the serious game.

Questions that will be asked:

1. What may cause a child with autism to feel anxious or affect their learning in a classroom setting?
2. What difficulties do children with autism face whilst trying to learn?
3. What accommodations could potentially be made in a classroom setting to combat this?
4. Can you discuss how a child with autism may react to sensory stimuli? Such as loud noises, unexpected noises, bright flickering lights.
5. How might the feeling of frustration affect a child with autism?
6. What is a meltdown/ shutdown and what can trigger it?
7. Do you think if a child with autism had control over certain things such as level difficulty it could improve learning?
8. For a child with autism, would it make any difference if they had someone they could relate to, such as an avatar that they could personalise, in a game?
9. For a child with autism, will it make a difference if learning is backed with meaning and context?
10. Is there any difference between how a neurotypical child might focus compared to a child with autism?
11. What effect does reassuring language have on a child with autism?
12. How about negative feedback?
13. Can you discuss common communication issues someone with autism might have?
14. How about the use of pictorial instructions?
15. Say if a child with autism was playing a game and the screen was very cluttered with lots to do, how would they react?
16. Obviously when playing a game and you get stuck on a level or task it can be annoying. How might a child with autism react to this?
17. Can you explain why a child with autism might need a bit more guidance whilst learning?
18. How might a child with autism react to a change in environment?
19. How do you think someone with autism would respond to a reward system?

Appendix 6) First Criteria Spreadsheets

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Minecraft			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	Y
Warning of loud noises	N	Y	N	N
Option to turn off loud noises	N	Y	N	N
Remove background noise	Y	N	N	N
Speech bubbles opt in	N	N	N	Y
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	N	Y
Warning of strobe lights	N	N	Y	N
Option to turn off strobe lights	Y	N	N	Y
No bright lights	Y	N	N	N
Options to change colour palettte	N	Y	N	N
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	Y	N
Select difficulty level	Y	N	N	N
Visual Personalisation				
Definable appearance	N	Y	N	N
Full range of characteristics available	N	Y	N	N
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	N
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	Y	N	N
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	Y	N	N	N
Absence of character or avatar 'death'	N	N	N	Y
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	Y	N	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	N	Y	N
Hint	Y	N	N	N
Commentary	Y	N	N	N
Practice Round	Y	N	N	N
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	Y	N	N
Rewards				
Cumulative rewards (rewards not removed)	Y	N	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	70%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	LightBot			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	N	Y	N	N
Option to turn off loud noises	Y	N	N	N
Remove background noise	Y	N	N	N
Speech bubbles opt in	N	N	Y	N
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	N	Y
Option to turn off strobe lights	Y	N	N	N
No bright lights	Y	N	N	N
Options to change colour palettte	Y	N	N	N
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	Y	N
Select difficulty level	N	N	Y	N
Visual Personalisation				
Definable appearance	N	N	N	Y
Full range of characteristics available	N	N	Y	N
Narrative Arc				
Narrative element present	N	Y	N	N
Social element present	Y	N	N	N
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	N	Y	N
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	Y	N	N	N
Absence of character or avatar 'death'	N	N	N	Y
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	Y	N	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	N	Y	N
Hint	Y	N	N	N
Commentary	Y	N	N	N
Practice Round	Y	N	N	N
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	N	Y	N
Rewards				
Cumulative rewards (rewards not removed)	Y	N	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	71%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Nanobot's Revenge			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	N	N	Y	N
Option to turn off loud noises	N	N	Y	N
Remove background noise	Y	N	N	N
Speech bubbles opt in	N	N	Y	N
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	Y	N
Option to turn off strobe lights	N	N	Y	N
No bright lights	Y	Y	N	N
Options to change colour palettte	N	N	Y	N
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	Y	N	N	N
Select difficulty level	Y	N	N	N
Visual Personalisation				
Definable appearance	N	N	N	Y
Full range of characteristics available	N	N	N	Y
Narrative Arc				
Narrative element present	N	N	Y	N
Social element present	N	N	Y	N
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	N	Y	N
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	Y	N	N	N
Absence of character or avatar 'death'	N	N	Y	N
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	Y	N	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	Y	N	N	N
Hint	Y	N	N	N
Commentary	Y	N	N	N
Practice Round	Y	N	N	N
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	N	Y	N	N
Avoid jumpcut	N	N	Y	N
Coutdown timer to significant change	N	N	Y	N
Rewards				
Cumulative rewards (rewards not removed)	Y	N	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	69%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Dream Hospital			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	N	N	N	Y
Option to turn off loud noises	N	N	N	Y
Remove background noise	N	N	N	Y
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	N	Y
Option to turn off strobe lights	N	N	Y	N
No bright lights	N	Y	N	N
Options to change colour palettte	N	N	N	Y
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	N	Y
Select difficulty level	N	N	N	Y
Visual Personalisation				
Definable appearance	N	N	N	Y
Full range of characteristics available	N	N	N	Y
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	Y
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	N	N	N	N
Modification of time constraints	N	N	N	Y
Positive Reinforcement				
Immediate and appropriate feedback	N	Y	N	N
Absence of negative language in feedback	N	Y	N	N
Absence of character or avatar 'death'	N	Y	N	N
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	N	N	N	Y
Uncluttered Screen	N	N	N	Y
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	Y	N	N
Hint	N	N	N	Y
Commentary	Y	N	N	N
Practice Round	N	N	N	Y
Reassuring Language	N	Y	N	N
Warning Messages				
Time-lines Schedules	N	Y	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	N	N	Y
Rewards				
Cumulative rewards (rewards not removed)	N	Y	N	N
Game broken down into manageable tasks/levels	N	N	N	Y
Criteria satisfaction	17%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	SimCity 4			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	N	N	Y	N
Option to turn off loud noises	N	N	Y	N
Remove background noise	N	Y	N	N
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	Y	N
Option to turn off strobe lights	N	N	Y	N
No bright lights	N	Y	N	N
Options to change colour palettte	Y	N	N	N
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	Y	N
Select difficulty level	N	N	Y	N
Visual Personalisation				
Definable appearance	Y	N	N	N
Full range of characteristics available	Y	N	N	N
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	Y
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	N	Y	N
Positive Reinforcement				
Immediate and appropriate feedback	N	Y	N	N
Absence of negative language in feedback	N	Y	N	N
Absence of character or avatar 'death'	N	N	N	Y
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	Y	N	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	Y	N	N	N
Hint	N	N	Y	N
Commentary	Y	N	N	N
Practice Round	N	N	Y	N
Reassuring Language	N	Y	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	N	N	Y
Rewards				
Cumulative rewards (rewards not removed)	N	Y	N	N
Game broken down into manageable tasks/levels	N	N	N	Y
Criteria satisfaction	60%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	DragonBox Element			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	N	N	Y	N
Option to turn off loud noises	N	N	Y	N
Remove background noise	N	Y	N	N
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	Y	N
Option to turn off strobe lights	N	N	Y	N
No bright lights	Y	N	N	N
Options to change colour palettte	N	N	N	Y
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	Y	N	N	N
Select difficulty level	Y	N	N	N
Visual Personalisation				
Definable appearance	N	N	N	Y
Full range of characteristics available	N	N	N	Y
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	N	N	N	Y
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	N	Y	Y
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	Y	N	N	N
Absence of character or avatar 'death'	Y	N	N	N
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	N	Y	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	N	N	Y
Hint	N	N	N	Y
Commentary	Y	N	N	N
Practice Round	Y	N	N	N
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	N	Y	N
Rewards				
Cumulative rewards (rewards not removed)	N	Y	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	57%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Fate of the World			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	Y	N	N	N
Option to turn off loud noises	N	Y	N	N
Remove background noise	Y	N	N	N
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	N	N	N	Y
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	N	Y
Option to turn off strobe lights	N	N	N	Y
No bright lights	N	N	N	Y
Options to change colour palettte	N	N	N	Y
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	Y	N
Select difficulty level	N	Y	N	N
Visual Personalisation				
Definable appearance	N	Y	N	N
Full range of characteristics available	N	Y	N	N
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	Y
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	Y	N	N
Positive Reinforcement				
Immediate and appropriate feedback	N	Y	N	N
Absence of negative language in feedback	N	Y	N	N
Absence of character or avatar 'death'	N	N	N	Y
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	N	Y	N	N
Uncluttered Screen	N	Y	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	Y	N	N
Hint	N	Y	N	N
Commentary	Y	N	N	N
Practice Round	N	N	N	Y
Reassuring Language	N	Y	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	N	N	N	Y
Coutdown timer to significant change	N	N	N	Y
Rewards				
Cumulative rewards (rewards not removed)	N	Y	N	N
Game broken down into manageable tasks/levels	N	N	N	Y
Criteria satisfaction	39%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Escape The Pacific			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	N	Y	N	N
Option to turn off loud noises	N	N	N	Y
Remove background noise	N	N	N	Y
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	N	Y
Option to turn off strobe lights	N	N	N	Y
No bright lights	N	Y	N	N
Options to change colour palettte	N	N	N	Y
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	Y	N	N
Select difficulty level	N	N	N	Y
Visual Personalisation				
Definable appearance	N	N	N	Y
Full range of characteristics available	N	N	N	Y
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	Y
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	Y	N	N	N
Positive Reinforcement				
Immediate and appropriate feedback	N	Y	N	N
Absence of negative language in feedback	N	Y	N	N
Absence of character or avatar 'death'	N	N	N	Y
Clarity of Instruction				
Pictorial instructions	N	N	N	Y
Instructions are simple and unambiguous	N	Y	N	N
Uncluttered Screen	N	Y	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	Y	N	N
Hint	Y	N	N	N
Commentary	Y	N	N	N
Practice Round	N	N	N	Y
Reassuring Language	N	Y	N	N
Warning Messages				
Time-lines Schedules	N	Y	N	N
Avoid jumpcut	N	Y	N	N
Coutdown timer to significant change	N	N	N	Y
Rewards				
Cumulative rewards (rewards not removed)	N	N	N	Y
Game broken down into manageable tasks/levels	N	Y	N	N
Criteria satisfaction	29%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Chill Panda			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	Y	N	N	N
Warning of loud noises	N	Y	N	N
Option to turn off loud noises	N	Y	N	N
Remove background noise	N	N	Y	N
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	N	N	Y	N
Option to turn off high pitched noises	N	N	Y	N
Warning of strobe lights	N	N	Y	N
Option to turn off strobe lights	N	N	Y	N
No bright lights	Y	N	N	N
Options to change colour palettte	N	N	N	Y
Option to change brightness	Y	N	N	N
Difficulty Levels				
Adaptive Progression	N	N	Y	N
Select difficulty level	N	N	Y	N
Visual Personalisation				
Definable appearance	N	N	N	Y
Full range of characteristics available	N	N	N	Y
Narrative Arc				
Narrative element present	Y	N	N	N
Social element present	Y	N	N	N
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	Y	N	N	N
Modification of time constraints	N	N	Y	Y
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	Y	N	N	N
Absence of character or avatar 'death'	Y	N	N	N
Clarity of Instruction				
Pictorial instructions	Y	N	N	N
Instructions are simple and unambiguous	Y	N	N	N
Uncluttered Screen	Y	N	N	N
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	N	N	Y
Hint	N	Y	N	N
Commentary	Y	N	N	N
Practice Round	Y	N	N	N
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	Y	N	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	N	Y	N
Rewards				
Cumulative rewards (rewards not removed)	Y	N	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	64%			

Design Criteria for Games for children with autism	Fully Implemented	Partially Implemented	Not Relevant	Not Implented
	Whyville			
Environmental Modifications				
Mute available	Y	N	N	N
Volume control	N	Y	N	N
Warning of loud noises	N	N	N	Y
Option to turn off loud noises	N	N	N	Y
Remove background noise	N	N	N	Y
Speech bubbles opt in	Y	N	N	N
Warning of high pitched noises	N	N	N	Y
Option to turn off high pitched noises	N	N	N	Y
Warning of strobe lights	N	N	N	Y
Option to turn off strobe lights	N	N	N	Y
No bright lights	N	N	N	Y
Options to change colour palettte	N	Y	N	N
Option to change brightness	N	Y	N	N
Difficulty Levels				
Adaptive Progression	Y	N	N	N
Select difficulty level	Y	N	N	N
Visual Personalisation				
Definable appearance	Y	N	N	N
Full range of characteristics available	Y	N	N	N
Narrative Arc				
Narrative element present	N	Y	N	N
Social element present	Y	N	N	N
Time Constraints				
Allow user to pause game	Y	N	N	N
Removal of time constraints	N	N	N	Y
Modification of time constraints	N	N	N	Y
Positive Reinforcement				
Immediate and appropriate feedback	Y	N	N	N
Absence of negative language in feedback	N	Y	N	N
Absence of character or avatar 'death'	Y	N	N	N
Clarity of Instruction				
Pictorial instructions	N	Y	N	N
Instructions are simple and unambiguous	N	Y	N	N
Uncluttered Screen	N	N	N	Y
Instructions retrievable throughout the game	Y	N	N	N
Guidance Available				
Walkthrough	N	N	N	Y
Hint	Y	N	N	N
Commentary	N	Y	N	N
Practice Round	N	Y	N	N
Reassuring Language	Y	N	N	N
Warning Messages				
Time-lines Schedules	N	Y	N	N
Avoid jumpcut	Y	N	N	N
Coutdown timer to significant change	N	N	Y	N
Rewards				
Cumulative rewards (rewards not removed)	Y	N	N	N
Game broken down into manageable tasks/levels	Y	N	N	N
Criteria satisfaction	39%			

Appendix 6) Second Criteria spreadsheets

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory		Minecraft			
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	Y	N	N	N
Practice and Drill	Taught skill is repeated in the game	N	N	N	Y
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	N	Y	N	N
Linearity	Increasing level of difficulty	N	N	N	Y
Attention Span	To keep concentration high, game has short duration per level	N	N	Y	N
Transfer of learned skills	Application of skills in different environments	N	N	N	Y
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	N	Y	N	N
Learner Control	Choices offered in game, for example duration	N	Y	N	N
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	Y	N	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	N	Y	N	N
Criteria satisfaction		39%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory		LightBot			
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	N	N	N	Y
Practice and Drill	Taught skill is repeated in the game	Y	N	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	N	Y	N	N
Linearity	Increasing level of difficulty	Y	N	N	N
Attention Span	To keep concentration high, game has short duration per level	Y	N	N	N
Transfer of learned skills	Application of skills in different environments	Y	N	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	Y	N	N	N
Learner Control	Choices offered in game, for example duration	N	Y	N	N
Psychology Theory					
Situated and authentic learning	Context offered in game	N	Y	N	N
Accomodating the learner	Choice to personalise aspects of the game	N	N	Y	N
Intermittent Feedback	Feedback offered per level completed and throughout game	Y	N	N	N
Criteria satisfaction		70%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory			Dream Hospital		
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	y	N	N	N
Practice and Drill	Taught skill is repeated in the game	N	Y	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	N	Y	N	N
Linearity	Increasing level of difficulty	N	N	Y	Y
Attention Span	To keep concentration high, game has short duration per level	N	N	N	Y
Transfer of learned skills	Application of skills in different environments	N	Y	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	N	Y	N	N
Learner Control	Choices offered in game, for example duration	N	N	N	Y
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	N	N	N	Y
Intermittent Feedback	Feedback offered per level completed and throughout game	N	Y	N	N
Criteria satisfaction		30%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory			SimCity 4		
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	Y	N	N	N
Practice and Drill	Taught skill is repeated in the game	Y	N	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	Y	N	N	N
Linearity	Increasing level of difficulty	N	N	Y	N
Attention Span	To keep concentration high, game has short duration per level	N	N	N	Y
Transfer of learned skills	Application of skills in different environments	Y	N	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	Y	N	N	N
Learner Control	Choices offered in game, for example duration	N	Y	N	N
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	Y	N	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	N	Y	N	N
Criteria satisfaction		74%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory			DragonBox Elements		
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	N	Y	N	N
Practice and Drill	Taught skill is repeated in the game	Y	N	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	Y	N	N	N
Linearity	Increasing level of difficulty	Y	N	Y	N
Attention Span	To keep concentration high, game has short duration per level	N	Y	N	N
Transfer of learned skills	Application of skills in different environments	N	Y	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	N	Y	N	N
Learner Control	Choices offered in game, for example duration	N	Y	N	N
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	N	N	N	Y
Intermittent Feedback	Feedback offered per level completed and throughout game	Y	N	N	N
Criteria satisfaction		70%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory			Escape The Pacific		
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	Y	N	N	N
Practice and Drill	Taught skill is repeated in the game	N	N	N	Y
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	Y	N	N	N
Linearity	Increasing level of difficulty	N	N	N	Y
Attention Span	To keep concentration high, game has short duration per level	N	N	N	Y
Transfer of learned skills	Application of skills in different environments	N	N	N	Y
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	Y	N	N	N
Learner Control	Choices offered in game, for example duration	N	N	N	Y
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	N	Y	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	N	Y	N	N
Criteria satisfaction		29%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory			Chill Panda		
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	N	Y	N	N
Practice and Drill	Taught skill is repeated in the game	Y	N	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	Y	N	N	N
Linearity	Increasing level of difficulty	N	N	Y	N
Attention Span	To keep concentration high, game has short duration per level	N	Y	N	N
Transfer of learned skills	Application of skills in different environments	Y	N	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	N	Y	N	N
Learner Control	Choices offered in game, for example duration	N	N	N	Y
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	N	Y	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	Y	N	N	N
Criteria satisfaction		65%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory		Whyville			
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	Y	N	N	N
Practice and Drill	Taught skill is repeated in the game	N	Y	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	N	Y	N	N
Linearity	Increasing level of difficulty	Y	N	N	N
Attention Span	To keep concentration high, game has short duration per level	Y	N	N	N
Transfer of learned skills	Application of skills in different environments	N	Y	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	Y	N	N	N
Learner Control	Choices offered in game, for example duration	Y	N	N	N
Psychology Theory					
Situated and authentic learning	Context offered in game	N	Y	N	N
Accomodating the learner	Choice to personalise aspects of the game	Y	N	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	Y	N	N	N
Criteria satisfaction		63%			

Attribute	Description	Fully Implemented	Partially Implemented	Not Relevant	Not Implemented
Behaviourist Theory		Nanobot's Revenge			
Interaction	Engagement in the game for the user	Y	N	N	N
Reward	Provides incentive for the user	Y	N	N	N
Practice and Drill	Taught skill is repeated in the game	N	Y	N	N
Cognitive Theory					
Incremental Learning	Given tutorials, examples and hints in game	N	Y	N	N
Linearity	Increasing level of difficulty	Y	N	N	N
Attention Span	To keep concentration high, game has short duration per level	Y	N	N	N
Transfer of learned skills	Application of skills in different environments	N	Y	N	N
Constructivist Theory					
Scaffolding	Support is offered to the user throughout the game	N	N	N	Y
Learner Control	Choices offered in game, for example duration	N	N	N	Y
Psychology Theory					
Situated and authentic learning	Context offered in game	Y	N	N	N
Accomodating the learner	Choice to personalise aspects of the game	N	Y	N	N
Intermittent Feedback	Feedback offered per level completed and throughout game	Y	N	N	N
Criteria satisfaction		58%			