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Parid-GO

A Personalised Augmented Reality Game to Reinforce Outdoor Physical Activity for People with Intellectual Disabilities

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Abstract

Parid-GO A Personalised Augmented Reality Game to Reinforce Outdoor Physical Activity for People with Intellectual Disabilities. This project aims to develop a dynamic content solution that is user centric. The rationale is that by allowing the participants to customize and use other themes, colors, etc., the participant will be more engaged and use the application more. Which in turn will increase their physical activity participation. Customization could be implemented at two varieties. First, the available customization could be limited to colors, background images, icons, etc. Second, an administrator can create a new theme, and upload images that must be categorized within that theme. For instance, if the theme is "vehicles", different images must be uploaded and categorized. The participants will then be exposed to these images and then asked to sort them.

Contents

1 Introduction

1.1 Background

According to the World Health organization almost 25% of adults globally do not participate in enough physical activity. The rising rates of physical inactivity have a negative influence on the health systems, environment, economy, social well-being, and quality of life(World Health Organization, 2019).

Adults with disabilities should exercise for at least 150 - 300 minutes per week of moderate effort, 75 - 150 minutes per week high intensity, or an equivalent combination of moderate and vigorous activity for significant health benefits.

Adults with impairments should start out with low levels of exercise and gradually increase the intensity, duration, and amount of their exercises over time.

When compared with the general population, people with intellectual disabilities experience worse health, more unaddressed healthcare requirements, and more barrier to access healthcare. Health attributes like as insufficient physical activity and weight problems are more common in adults with IDs than in the broader adult population. About half of this group have been found to lead sedentary lifestyles, while 40% have low levels of physical exercise (Haveman et al., 2011). A Norwegian study found that the typical Nordic advice of at least 30 minutes of moderate physical activity each day was followed by 7% of men and 8% of women with Down syndrome. In the world, 9% of people with intellectual disabilities met the WHO's recommendation for only the bare minimum of physical activity, according to a recent analysis. (Dairo et al., 2016). The likelihood of achieving the suggested levels of physical activity was favourably correlated with male gender, younger age, milder intellectual handicap, and those living alone. It is believed that children with intellectual disabilities would be more likely to face this problem to a greater degree because young adults' increased sedentary behaviour has become a notable issue in the general community. (Winther et al., 2014). Obstacles like a lack

of motivation or a lack of resources and opportunities might also contribute to low levels of physical activity.

1.2 Scope and Research Problem

1.2.1 Rationale for problem statement in the thesis

As a condition requiring "significant limitations in both intellectual functioning and adaptive behavior as expressed in conceptual, social, and practical adaptive skills," intellectual disability is defined. This condition first appears before the age of 18 (Schalock et al., 2010). Intellectual disability is categorized into four levels; mild (IQ 50–69), moderate (IQ 35–49), severe (IQ 20–34) and profound (IQ 20 or below) (World Health Organization, 2019). According to reports, 85% of people with intellectual disabilities have mild disabilities, compared to 10% who have moderate disabilities, 4% who have severe disabilities, and 1% who have profound disabilities. (Patel et al., 2020).

Alongside or concurrently with other syndromes, diseases, or disabilities, intellectual disabilities (ID) can arise. It is typical for people with ID to also have other cognitive or physical impairments, such as Cerebral Palsy, Autism Spectrum Disorder, or other neurological conditions. ID is also a part of the genetic syndromes like for instance Down syndrome or Fragil-X.

When developing new interventions, the heterogeneity of the group should be considered. That is why this master thesis will focus on adding a more dynamic content to an already excising AR solution to increase motivation for physical activity. The rationale is that by allowing the participants to customize and use other themes, colors, etc., the participant will be more engaged and use the application more. Which in turn will increase their physical activity participation. Customization could be implemented at two varieties. First, the available customization could be limited to colors, background images, icons, etc. This can be done by adding default available themes. Second, an administrator can create a new theme, and upload images that must be categorized within that theme. For instance, if the theme is "vehicles",

different images must be uploaded and categorized. The participants will then be exposed to these images and then asked to sort them.

1.2.2 Problem Statement

How can we design and implement a personalised mobile game for people with mild to moderate intellectual disability to stimulate interest in outdoor physical activity by adding more dynamic contents?

1.2.2.1 Sub Problems

In the previous project sorterius we find that it could fit users with various severities of intellectual disabilities which involved different levels.

But here we implement various themes among which the user can choose one or many based on their interest.

> 1. How can we design various modes that could match the interest of users with different severity of intellectual disability?

People with ID seem to lose interest in short period of time. To have them into continued involvement we need to implement certain features that encouraged them for example sounds and effects like particles or object explode after certain stage.

> 2. How can we improve the game application to encourage continued usage?

The earlier application looks discrete, we need to improve the user interface more captivate for the users in terms of sounds and visualization using the suggested colors.

> 3. How can we design the application to make visualization attractive?

Not all the users would go for the existing theme! Some may have their interest beyond what is default. In that case the app should also have an option in which the parent or caretaker of the

user can add custom theme that the user is particularly interested in. The scope for this sub problem needs to be evaluated.

> 4. How can we implement a custom theme option for the supervisor of the user to append user specific theme materials?

1.3 Assumption and limitations

Involving people with intellectual disability to do physical activity is a challenging task. Though people have tried to make applications that makes this possible, we believe that our input to this task will be the real motivation factor among most of them because this solution provides a user centred product.

We want to develop an application using Augmented reality technology that works for people with mild to moderate level of Intellectual Disability assuming that they can interact with this technology using their own mobile device. People with these levels of ID has almost similar cognitive capability. The potential users would be those who may not need much supervision to go outdoors. Yet the application is not restricted to them because other users can still use it with the guidance of parents or care givers. This projects main aim is to make as many users as possible to get involved in physical activity and get benefited from it.

For now, the testing of the application is limited to usability testing. So far, the application is evaluated by teachers and psychologists. Also, studying fitness signs over time is essential when testing an application intended to promote physical activity in order to assess the impact it has on the intended users. We still need to check if it is possible to test the application with the user group because that can give the true evaluation of the gameplay to the user. Furthermore, it would give the most valuable feedback for the application.

1.4 Organization

The structure of the remainder of the thesis is covered in this section.

Chapter 2: Conceptual framework

Conceptual framework provides relevant project-related basic information. This chapter provides background knowledge on intellectual disability, serious video games, user centric design and the most cutting-edge augmented reality games. This chapter also presents the results of the literature review conducted for this project and covers topics of creating an accessible user interface for those with intellectual disability.

Chapter 3: Methods and Materials

This chapter presents the research paradigm along with the methodologies employed in the design, execution, assessment, and usability of the project.

Chapter 4: Requirements Specification

Requirements Specification describes how the project identified requirements. Also, the functional requirements as well as non-functional needs are defined.

Chapter 5: Design and Implementation

This chapter present the design of the application by discussing the game environment, all the modes and levels of the application. Also, this chapter makes the overall design and design decisions clearer. A complete explanation of the development procedure and specific implementation information are presented in this chapter.

Chapter 6: Evaluation and Result

The tests and results conducted on the game application is presented in this chapter including usability tests along with the general feedback.

Chapter 7: Discussion

The findings of the evaluation are given and examined. Additionally, the issues and obstacles encountered throughout the project phase are discussed along with the future work.

Chapter 8: Conclusion

Presents the concluding remarks and summarizes the project.

2 Conceptual Framework

2.1 Intellectual Disability

Individuals who have intellectual disabilities typically have low levels of cognitive functioning and adapting to certain behaviours. Fundamentally, this disability is brought on by neurodevelopmental disorders or genetic issues and affects people since childhood, making it challenging to diagnose. However, there is a significant likelihood that these individuals have autism. Thus, neurodevelopment is broad.

In most cases, it is during infancy and childhood when intellectual disability's clinical symptoms and indicators are first noticed. Based on the age at presentation, the precise aetiology, and the degree of cognitive deficit, there are several major clinical signs and symptoms that are indication of intellectual disability. Infants and young children with severe intellectual deficit are quite likely to have an underlying ailment, and they are also very likely to exhibit early clinical signs of the underlying disorder. In contrast, with the majority of children having mild intellectual deficits, the probability to identify a definite root cause or clinical signs is very low, and they might not even be recognized with intellectual disability until later in childhood. Some kids with mild ID could not be noticed until they are 5 to 9 years old (Patel et al., 2020)

2.1.1 Mild

Eighty-five percent of people with intellectual disabilities have mild severity, reducing the likelihood that they would be diagnosed with ID before they are five or six years old. Mild ID patients have measured IQs between 50-55 and 70. Individuals who have mild ID have trouble learning and understanding complicated linguistic and academic skills. They can perform academically up to a 4th or 5th grade level. In addition to language difficulty, they also have difficulty in arithmetic and writing skills. They can acquire fundamental reading, writing, and

math abilities with the right assistance. Most people can fill out a basic job application and compose simple letters.

Adolescents and adults with mild ID still struggle with executive functioning skills like organising, prioritising, planning, and abstract thought. Additionally, they exhibit impairments in short-term memory activities. People with mild ID are more susceptible to being misled by others. They exhibit a limited capacity to understand or interpret social language and interaction standards effectively, and their social behaviour is frequently viewed by others as immature or inappropriate.

People with mild intellectual disabilities can learn the majority of skills required for daily domestic, practical, and self-care tasks with the right help. They may possess the necessary skills to preserve their independence in everyday activities and find work that pays well. They can pick up basic job-related skills including arriving on time for work, staying focused, and engaging in proper social interactions with peers. (Patel et al., 2020)

2.1.2 Moderate

About 10% of ID sufferers are moderately severe, and by the time they are 3 to 5 years old, they are likely to be identified as such. The range of measured IQs for those with moderate ID is between 35 and 49 and 50 to 55. In children with mild ID, the rate of basic language skill acquisition is weak. People with moderate intellectual disabilities have restricted language learning and development abilities as well as learning and academic skill competency. People with moderate ID exhibit substantial impairments in their ability to read, write, do math, and perform other tasks that call for understanding fundamental concepts. People with moderate ID may learn some fundamental skills, such as the capacity to copy information, match numbers to numbers of items, and read sight words.

When they are adults, people with moderate ID have a mental age of roughly 6–8 years. Individuals with moderate intellectual disabilities require significant continuing care in order to maintain their independence in daily tasks and to continue working. People with moderate

ID may be able to learn the essential skills needed for everyday life and employment with continued support and instruction. They require ongoing oversight and direction while carrying out daily responsibilities and tasks connected to their jobs. When it comes to self-care and activities of daily living like eating, clothing, eliminating, and maintaining personal hygiene, a person with moderate ID can become relatively independent (Patel et al., 2020).

2.1.3 Severe

A high likelihood exists that a person with severe ID, which accounts for about 4% of all people with ID, will have it identified by the time they are 3 years old or younger. People with severe ID typically have an IQ between 20 and 25, and between 35 and 40. Persons with severe ID may also have motor impairments and other related problems that further restrict their ability to think critically and adapt. This is in addition to having a substantial deficit in intellectual functioning. The mental age of people with severe ID ranges from 3 to 5 years old when they are adults. When it comes to daily living activities, people with severe ID require considerable, ongoing, consistent, and lifetime help and are care reliant.

Severe ID patients have greatly constrained language and communication skills. Their spoken language is severely restricted, and they may only be able to communicate using single words or short phrases. Utilizing augmentative communication techniques may help them communicate more effectively. To express fundamental requirements, they frequently employ gestures. Severe ID patients have considerable difficulties with notions of quantity, time, money management, and problem solving. People with severe ID tend to engage and form relationships primarily with their immediate families and caregivers.

The self-care and personal hygiene of a person with severe ID require substantial support in all daily living tasks. They need constant supervision since they are unable to make correct judgements or decisions that could harm their own or others' wellbeing. Self-harm is a major problem in those with severe ID who engage in maladaptive behaviour. (Patel et al., 2020)

2.1.4 Profound

One percent of people with ID have profound ID and it is noticed by the time they are two years old. People with profound ID have IQs between 20 and 25. People with profound ID function at roughly a 3-year-old mental age and require high-intensity, all-encompassing support in all circumstances. They are significantly constrained in terms of mobility, communication, sanitation, and self-care. They are totally dependent on supervision and may require comprehensive nursing or domestic care. The development and use of motor, adaptive, or social skills are further constrained in people with severe ID who also have additional impairments such motor and sensory abnormalities. Because the validity and reliability of standardised tests of intelligence are not firmly demonstrated when used in individuals with cognitive processing that is lower than the 0.003rd percentile person, severe and profound ID are primarily distinguished based on variations in limitations of adaptive behaviour.

People with profound ID have significant conceptual or academic disabilities. It is feasible for a person with significant ID who does not have accompanying motor or sensory impairments to gain some self-care skills with rigorous and persistent education and support. With the aid of augmentative communication techniques, some people might be able to gain some capacity for nonverbal communication. A person with profound ID may react to family members or caregivers by making motions and displaying emotional expressions on their faces. A person with profound ID requires ongoing supervision and is completely dependent on others for all daily activities. (Patel et al., 2020)

2.2 Serious Games

A digital game that was made with at least one additional purpose in mind in addition to entertainment is referred to as a serious game (e.g., learning or health). These additional purposes are names characterizing goals.() Player can use serious game in their leisure time, it is not necessary to have a formal setting. It can be of various genre but often used for learning.

Based on the characterizing goals serious games are categorized. This application comes under one of those categories called exergames. **Exergames** Apart from entertainment this project

help to motivate the user to involve in outdoor activity by including customization of modes. The different modes also help the user in cognitive thinking while they categorize the objects.(Bellotti et al., 2013; Gao & Chen, 2014)

2.3 Augmented Reality

In order to create a mixed reality, augmented reality (AR) combines components of the actual real-world environment with computer-generated pictures. The augmentation is often performed in real time, incorporating ambient factors and semantic context. The information about the immediate actual world is made interactive and digitally useful by applying the most recent AR techniques and technologies. Augmented Reality enhances the user's interaction with the world. It has the ability to also augment senses like touch and hearing(Carmigniani & Furht, 2011; Gao & Chen, 2014).

This project focus on outdoor activity using augmented reality technology. AR Quake is the first outdoor mobile AR game, developed in 2002. In the recent times, mobile AR become more widespread as mobile hardware's processing power and image processing algorithms continue to advance(Billinghurst et al., 2015; Carmigniani & Furht, 2011).

2.3.1 Recent AR Games

Pokemon GO

Pokemon GO is an augmented reality mobile game released in July 2016 and developed by Niantic together with Nintendo and The Pokemon Company. The game combines virtual reality world of Pokemons with the real world that motivates players to explore their environment and grab pokemons using their mobile devices. This game uses GPS and Augmented Reality technology to create an intuitive experience as it provides real-world experience such as parks, streets, and other locations.

Ingress

Ingress is also an augmented reality mobile game developed by Niantic which was released in 2012. The key difference between Pokemon Go and Ingress is their gameplay and the objectives. In this game players are set in a science-fiction world where they engage in a global battle to control Exotic Matter (XM). This game also allows player to explore the real world while they participate in a clandestine battle between two factions namely the Enlightened and the Resistance. The game boundary revolves around searching for the Exotic Matter which is a mysterious energy source that leaked into the world through portals. A player should either harness the power of XM for the Enlightenment or defend the humanity from its possible dangers.

Jurassic World Alive

Jurassic World Alive is an augmented reality mobile game developed by Ludia Inc. and released in 2018. The game play is set in Jurassic Worlds where the players explore the real world while collecting and battling with virtual dinosaurs. Players can also create hybrid dinosaurs by collecting and combining DNA of different dinosaur species. The game provides immersive experience for those who are fans of the Jurassic Park and dinosaurs.

2.3.2 AR games for people with ID

Interactive augmented reality using Scratch 2.0 to improve physical activities for children with developmental disabilities.

This research explores the utilization of augmented reality technology together with Scratch 2.0 programming platform to enhance physical activities for children with developmental disabilities. AR allows this game to create interactive and engaging experiences to the children by overlaying digital elements onto the real world. Scratch 2.0 is used as a tool to tailor the design and AR activities to the requirements and abilities of the children with developmental disabilities. The game primarily focuses to improve physical activity from basic body movements to exercises by providing inclusive and customized experiences.

Dyrejakten

Dyrejakten is a mobile exergame app that uses augmented reality technology to encourage people with intellectual disabilities to do physical activity. The game allows the user to walk around in the real world while collecting virtual animals. It has four different animals in the gameplay.

Sorterius

Sorterius (Stellandar,2022) is a mobile exergame app that utilizes augmented reality technology together with Unity game engine to motivate outdoor physical activities for youth with mild to moderate level of intellectual disabilities. AR allows this game to create interactive and engaging experiences to the player by overlaying virtual elements onto the real-world environment. The game primarily focuses to improve physical activity basically outdoor walk by providing inclusive and customized experiences. It uses mascot to guide the user throughout the game play. While the player walks around the real world, virtual garbage are spawned after particular number of steps that the player chooses at the beginning. The player is expected to collect the garbage and through them to the bins according to their type. The game also allows players to choose different levels of difficulties based on which the type and number of bins changes.

2.4 State of the art

2.4.1 Data sources and Exclusion criteria

To form the foundation for the project the following databases was searched:

- ACM Digital Library

- Embase

- Medline

• IEEE Xplore

• PubMed

• Web of Science

Exclusion criteria

Searching for literature was done using some basic exclusion criteria:

• The paper had to be in English.

• The paper had to involve a gaming perspective.

• The paper had to contain a form of physical exercise or motivational factors.

• Full text had to be available from the university library to be included.

Screening phases Three screening phases was used:

1. Based on title

2. Based on abstract and introduction

3. Based on the main content

3 Methods and Materials

The methods chapter describes the paradigms used for the research as well as the materials and evaluation methods.

3.1 Research Paradigms

The research is organized in accordance with a certain management structure following the framework given in Computing as a discipline(Billinghurst et al., 2015) (Denning et al., 1989).

3.1.1 Theory

1. characterize objects of study (definition)
2. hypothesize possible relationships among them (theorem)
3. determine whether the relationships are true (proof)
4. interpret results

3.1.2 Abstraction

1. form a hypothesis
2. construct a model and make a prediction
3. design an experiment and collect data
4. test the system

3.1.3 Design

1. state requirements
2. state specifications
3. design and implement the system
4. test the system

Until the system effectively satisfies the requirements, these processes should be iterated numerous times. Over time, requirements may change as the necessity for additional crucial features is discovered. This project can also be viewed in the context of the experimental scientific process, which includes the phases of developing a hypothesis, building a model, and

making a prediction, designing an experiment and gathering data, and then analysing the outcomes.

3.2 Materials

A variety of tools were employed to produce the solution suggested in this project. The following hardware and software were utilised in the game's development.

3.2.1 Software

- Unity, a cross-platform game engine created by Unity Technologies. The version used was v.2021.3.6f1.
- Google ARCore for Unity
- Rider for Windows PC was used as the text editor for the scripting functionality in Unity. All things not specified in the Unity editor is specified in the code-behind scripts written in C#.
- OS: Windows 11 Home, Version 21H2 RAM 8 GB

A variety of tools were employed to produce the solution suggested in this project. The following hardware and software were utilised in the game's development.

3.2.2 Delevopment Platform

Unity and Rider are the two deveopmet platforms.

The earlier version of this application was developed in Unity, hence continued in the same. We have used the free version of Unity. Rider has better integration with unity and makes developement easy.

Unity

Unity, a cross-platform game engine created by Unity Technologies. The version used was v. 2021.3.6f1.

Unity3D is an integrated development environment for creating interactive media typically video games. Unity game engine has the ability to deploy to a wide variety of target.
platforms using the same code and assets. It allows developers to implement the application in three ways: Unity JavaScript, C# and Boo. We have used C# for the development of this project and it gives a complete and precise control. Unity has a unique scripting characteristic called visual properties that allows to modify the public variables in the editor. This feature helps assign right values quickly in the editor itself. Unity also provides a marketplace called Unity Asset Store for developers where they can purchase and also sell assets and packages.(Denning, 1989; Menard & Wagstaff, 2012)
Google ARCore for Unity(Lanham, 2018; Menard & Wagstaff, 2012)

Rider

Rider for Windows PC was used as the text editor for the scripting functionality in Unity. All things not specified in the Unity editor is specified in the code-behind scripts written in C#.
JetBrains Rider is an editor that has built in unity support. Rider will automatically configure it as the Unity's default editor for C# scripts. Rider has a two-way communication with unity that enables to switch the play mode. It provides Unity-specific inspections and code analysis for C# that warns the developer about inefficient code usage including coding hints. As soon as the changes are saved in Rider, the corresponding error, warning, or message is viewed in Unity editor logs immediately. On top of all these, Rider highlights usage of unity files including scenes, assets and prefabs into the code and clicking the link will find those usages, even inside Unity files.(2018)

3.2.3 Hardware

Samsung Galaxy FE, used for testing and launch of the game application. The physical device that development has taken place on, and the device that was deployed on the institution where testing took place.

3.3 Literature Review

A literature review is "an important chapter in the thesis, where its purpose is to provide the background to and justification for the research undertaken" (Bruce, 1994, p. 218). The objective of this literature review is to find the state-of-the-art, which would help us gain knowlegde of what has been done earlier so that it is not repeated and what needs to be done in the present and future.

Question for Literature

> Does there already exists any technology that helps motivate people with Intellectual disability to go for outdoor activity?

The main objective of this literature review is to find all the papers that are relevant to technologies involved in the motivation of people with intellectual disability to do physical activity.

This literature review should also include similar chronic diseases like autism and age is not used as the factor to screen a paper.

A systematic literature search was conducted over 6 databases during January 2023 and conducted several times throughout the thesis period. These are the six databases.

ACM (Comprehensive full-text collection of articles, conference papers and books in informatics, IT, and telecommunications).

IEEE (Comprehensive full-text collection of articles, e-books, conference proceedings, technical standards and related material in computer engineering, electronics, and electrical engineering.)

Embase (Covers the most important international biomedical literature from 1947 to present. Contains Medline but has especially strong coverage of pharmaceutical and pharmacological topics.)

Medline (Widely recognized database as the premier source for bibliographic and abstract coverage of biomedical literature. Contains references to journal articles within medicine, preclinical sciences, odontology, nursing, veterinary medicine, and other areas related to the health sciences.)

PubMed (Free access to references from more than 5500 international journals in medicine, nursing, odontology, veterinary medicine, health services and biomedical research. Consists of MEDLINE (1966-), OLDMEDLINE (1946-65), PubMed in Process (references not yet indexed in Medline) and references "as supplied by publisher" (subjects not indexed in Medline)

Web of science (Access to Science citation index expanded, social science citation index, Arts and humanities citation index, and Conference proceedings citation index.)

The first part of the query was used to find all the papers related to the user group.

("intellectual disabilit*" or "developmental disabilit*" or "cognitive disabilit*" or "autis*" or "down* syndrome")

The second part of the query was used to find papers related to physical activity.

(exercise* or "physical activit*" or "sedantary behavi*" or "motivation*" or "outdoor activit*")

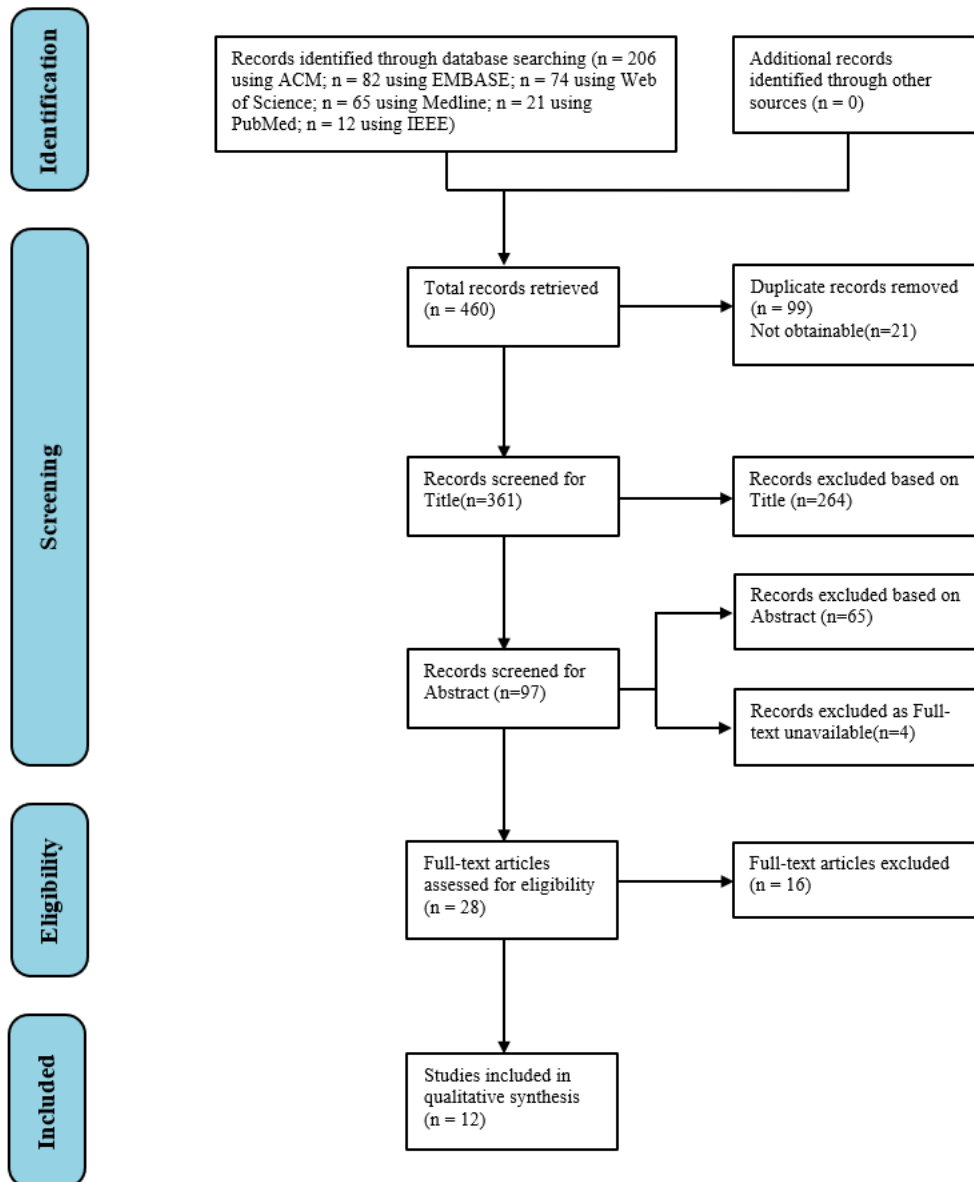The last part was used to find all the technology related papers.

("serious game*" or "video game*" or "exergame*" or gamification* or "augmented reality" or "mobile technology*" or telemedicine* or "user-cent*d design" or "personali*ation")

The complete search query fetches all the papers that involves technology usage toward motivation in physical activity in the target user group or similar user groups.

("intellectual disabilit*" or "developmental disabilit*" or "cognitive disabilit*" or "autis*" or "down* syndrome") and
(exercise* or "physical activit*" or "sedantary behavi*" or "motivation*" or "outdoor activit*") and
("serious game*" or "video game*" or "exergame*" or gamification* or "augmented reality" or "mobile technology*" or telemedicine* or "user-cent*d design" or "personali*ation")

The search resulted in 439 records. EndNote, a reference management software is primarily used throughout the literature review process. The software allowed to import, organize, and maintain bibliographic records. The screening included different levels. Firstly, duplicates were removed with the help of the software (79); It was further checked manually for missed out duplicates (20). Secondly, papers were included based on title relevant to the objective of the study (97). Thirdly, the abstract of each paper is read through for further screening. Based on the abstract of the papers, they were categorized into various area of focus that involved motivation, customization and technology like Augmented reality, Serious and Exergames. After this step we ended up with (32) papers. Finally, full text was gone through and 9 papers most relevant to the objective was included. The prisma diagram for the literature study is given below. The essence of included paper is given in *the following figure*.

| Identification | Records identified through database searching (n = 206 using ACM; n = 82 using EMBASE; n = 74 using Web of Science; n = 65 using Medline; n = 21 using PubMed; n = 12 using IEEE) | Additional records identified through other sources (n = 0) |

Total records retrieved (n = 460) → Duplicate records removed (n = 99) Not obtainable(n=21)

Records screened for Title(n=361) → Records excluded based on Title (n=264)

Records screened for Abstract (n=97) → Records excluded based on Abstract (n=65)

→ Records excluded as Full-text unavailable(n=4)

Full-text articles assessed for eligibility (n = 28) → Full-text articles excluded (n = 16)

Studies included in qualitative synthesis (n = 12)

Screening

Eligibility

Included

Prisma Diagram for the Literature Review

A summary of these 12 qualitative articles is given in the following Table that includes the target group, number of participants, technology used for the research. It also includes the aim of the project, the methods they followed to accomplish their aim and the results with findings.

Authors	Participants	Target Group	Technology	Goals	Method	Result	Findings
Lin & Chang, 2015	3	Children with Developmental Disabilities	Interactive augmented reality	To improve physical activities	1.Experimental design adopted an ABAB reversal design. 2.Data was collected over 2 months, with 2–3 sessions per day, 3–5 days a week, with each session lasting 90s	Intervention had a significant effect	To use dynamic pictures and sounds to focus on physical activities.
Lee et al., 2018	49	Adults with Autism Spectrum Disorder	Augmented Reality	To Increase Physical Activity	Require users to solve puzzles and quizzes while engaging in PA to earn competitive rewards in and out of home environments	Provides users with daily and weekly progress information, including walking steps, distance, time spent for PA, burned calories, puzzle score, and visualized tracking.	Important to maximize user accessibility and intrinsic interests toward mobile apps using gamified visual feedback and AR technique
Kim et al.,2020		Adults with Autism Spectrum Disorder	Mobile game with User-centered design	Describe the iterative design inquiry process of PuzzleWalk, a gamified, physical activity-promoting mobile app designed for adults with ASD	To report design rationales, lessons learned, and salient factors informed through a series of design inquiries of a mobile app for adults with ASD. • To demonstrate the effectiveness of a BCTs-based smartphone application, PuzzleWalk, designed through UCD. • To assess the perception of use and feasibility of PuzzleWalk in increasing PA in adults with ASD through a one-month field study	Reports the design rationales and lessons learned across four user-centered design phases with ASD experts and adults with ASD, including user requirement gathering, iterative participatory design, usability evaluation, and field deployment.	The design insights generated from this work could inform future research focusing on designing sociotechnical systems, games, and interventions for people with ASD

Authors	Participants	Target Group	Technology	Goals	Method	Result	Findings
Michalsen et al., 2020	60	Individuals with ID aged 16 to 60 years	Exergame	To promote outdoor PA To provide tailored mHealth Support	1. Baseline Assessment. 2.Randomization • Intervention Group (30) • Control Group (30)	Detailed plan to produce new knowledge about mHealth to support PA in individuals with IDs.	mHealth intervention for PA can improve self-efficacy in activities, social support, health conditions such as blood pressure, and the results of physical performance tests.
Johnson, K. T. and R. W. Picard (2017)		Children with Autism or Neurodevelopmental Differences	Mobile app	SPRING is a learning system designed to bolster development in young children, especially those who benefit from highly personalized learning aids	1. Automate quantitative data acquisition. 2. Optimize learning progressions through customized, motivating stimuli. 3. Encourage social, cognitive, and motor development in a personalized, child led play environment	Motivation-driven learning	1.Tailored to the child, rapidly and fully customizable. 2.Customizable across three important domains: • the activity. • the developmental level of the activity. • the feedback.
Caro, K., et al. (2018).	10	Adults with Developmental disabilities aged 23 and 36	Exergame	Use of exergames at helping and motivating adults with DD to perform visual-motor coordination exercises	1.Participant played the exergame for approximately 6 minutes on 3 sessions over the course of a week. 2.Semi-structured interview about their experience with the exergame. 3.Participants answered a questionnaire to measure their game experience.	Participants, felt play fun and motivated to play the exergame again. Liked the exergame's pictures, animations, and music. Commented that they enjoyed the idea of using their arms to make the animal avatar catch bugs.	Exergames have the potential to help and motivate adults with exergames have the potential to help and motivate adults with DD

Authors	Participants	Target Group	Technology	Goals	Method	Result	Findings
Simoes, M., et al. (2018)	20	Autism spectrum disorder	Serious game	To make players familiar with the process of taking a bus and to validate if it could be used effectively to teach bus-taking routines and adaptive procedures.	Players were placed in a three-dimensional city and were submitted to a set of tasks that involved taking buses to reach specific destinations.	A statistically significant increase in the measures of knowledge of the process of riding a bus, a reduction in the electrodermal activity (a metric of anxiety) measured inside the bus environments, and a high success rate of their application within the game (93.8%).	1.Game proved to be potentially useful in the context of emerging immersive VR technologies. 2.Serious games, using these technologies, can be used effectively in helping people with ASD become more independent in outdoor activities, specifically regarding the use of buses for transportation.
Finkelstein, S., et al. (2013)	10	Children with Autism	Virtual Reality	Study of physical activity and motivation level	1.By giving informed consent sheets. 2.By directly speaking to the child about what they would be doing in the study 3. By giving families the opportunity to ask question.	Immersive VR exergame.	Reported high levels of enjoyment and indicated they would exercise more often if such games were routinely available.
Pena, O., et al. (2021)	12	Children with Autism	Multimodal exergame	Supporting vestibular therapy	1. Using Circus in Motion 2. Using a foam puppet commonly used as a visual support during a traditional therapy.	1.Participants seemed more engaged when playing with Circus in Motion than during the traditional therapy. 2.Increased PA and the number of completed repetitions.	For every child, the exergame suggests a different difficulty level according to child performance.

Authors	Participants	Target Group	Technology	Goals	Method	Result	Findings
Guerra, M. S. D., et al. (2019).	24	Youth with Down Syndrome aged 14 to 46.	Virtual and Augmented 3D Environments	To perform gestures with the help of 3D environment	1.3D Gesture Selection. 2.Analyse the gestures. 3.Create task for each gesture	3D gestures better to use than 2D	When it comes to the design of VR or AR applications gestures prove to be best suited for all users.
Bossavit, B. and S. Parsons (2018)	6	Teenagers with high functioning ASD	Serious Games	A pilot study that explores and analyses an academic-based educational game that was co-designed with and for young people with ASD.	Learn Geography-specific knowledge and integrates several strategic features so that users can collaborate against the computer or compete against each other.	1. The participants were positive about their enjoyment, motivation, and social engagement. 2.Increase their knowledge in Geography content	1.Players' level of competitiveness not only influenced the experience within the game but also the interaction within the peer teams. 2.Considerable benefits of including children with ASD in the design process
Caro, K., et al. (2017)	7	Children with severe autism aged 7 to 10	Exergame	Hypothesize that exergames supporting motor therapeutic interventions and alleviating such attention and motor challenges could help children with severe autism to develop the necessary coordination skills needed to follow up visual targets.	7-weeks deployment study of the use of FroggyBobby.	1.Participants maintained their attention for the total duration of the therapy. 2.Reduced their aimless limb movements and developed aimed limb movements, as a result of weeks of usage of the exergame	Performance of each child in the exergame is time-dependent and according to the motor capabilities of each child

4 Requirements Specification

4.1 Application Requirements

In this chapter the requirement specifications for the project are described. The functional and non-functional requirements are listed based on the Volere requirements specifications (2022; Robertson & Robertson, 2000) . The requirements are taken basically from the future work of previous project Sorterius and feedback from teachers and experts in the field.

4.1.1 Functional requirements

Functional requirements bring the usefulness to the user. It defines the functionality of the application.

The game is inspired by Magnus Stellander's work named Sorterius (Stellandar,2022). Sorterius uses Augmented Reality to clone trash in the real-world environment. The user has to move certain number of steps to find the trash through their device camera and throw the trash in the right bin. It also includes functionalities like choosing the difficulty levels, selecting the number of objects to be cloned. Thomas has created a persistent storage for sorterius.

Existing themes

The game should begin with a page listing the existing themes from which the user can choose. These lists of existing themes should be contained within a scroll and each theme button should have icons that denote the difficulty levels available for that theme. There should be a button to open the theme. It should take to the choose difficulty level page if the theme has medium or hard levels. If it has only easy level, then it should directly start the game session.

For easy level, the objects spawned should just be collected without any tasks.

For medium level, after each object is collected there should be tasks that allows the user to tap the right category. Hard level is similar to medium level with even more difficulty in the tasks.

The tasks involved are specific to the themes chosen and every time it should be checked if the task is accomplished. While the object appears the music specific for the theme should be played.

Customization

There should a page for customized themes. Here the parent or the carer should have an option to go the gallery. They should be able to select multiple objects from the gallery. The number of images to be selected should rage between 5 to 20. They should be prompted to confirm whether to save the chosen images in a theme. If they choose not to save then, it should directly start to spawn. Otherwise, they should be able to give a name for it. Then it should be added to the page which they use for later. This spawning should be similar to easy level spawning.

Pivot Functionality

The game should be able to start.
User should be assisted throughout the game.
The game shoud be able to stop

Game functionality

The game should begin with a page listing the existing themes.
The list of existing themes should be contained within a scroll.
User should be able to choose from the list of themes.
There should be a button to open the theme.
If the theme has included medium or hard level, Open button should take to the choose difficulty level page.
User should be able to start the game session.
User should be able to view their environment through the camera.
User should be able to pick the object.

The gameplay should include tasks for the user in the medium and the hard level.
The gameplay should check if the task is accomplished.

Steer and Theme Specific:

Each theme button should have Steer icons that denote the difficulty levels available for that theme. (Choose theme page)
Each difficulty button should have Steer icons that denote how difficult the level is. (Choose difficulty page)
The gameplay should be able to spawn theme specific objects.
The gameplay should play theme specific sound.

The Steer should appear throughout the game representing the theme.

Mention Different pages

4.1.2 Non-functional Requirement

User should be able to set up the game without requiring knowledge in technology.

The game need not be so obvious to the user that it's developed for their physical activity.

Appearance and Usability

The user interface must be accessible for users with intellectual disabilities. People with intellectual disabilities can have bad reading abilities and impaired visual acuity. The designed interface should follow guidelines created for people with intellectual disabilities. Visuals and audio should be informative but not a disturbance

Safety and Security

The application must be safe to use when players walk around looking for objects. Paying the game must not put the users in physical danger. Data stored in the application must not include any information that could identify the user. Sharing physical activity data must be done on secure channels and anonymously.

Language

The content of the game must be in Norwegian. The targeted user group is Norwegian, and they must be able to understand messages and instructions.

5 Design and Implementation

5.1 Game Scenario

While the user starts the application, they are asked to choose a theme of their interest. The game six different existing themes namely animal, birds, colors, dinosaur, vehicles, and unicorns. These themes were chosen for the user group as they are interesting to them. For each theme there is a pictorial representation, which are later used as steer (Look into objects) throughout the theme. As the next step the user is asked to choose the level of difficulty. The number of the objects to be spawned and the categorisation of the objects are based on the difficulty level.

Once the game starts, the real-world environment around the user is seen through the phone by using the camera. The steer assists the user to start moving forward to find the object around. While they cover certain number of steps, one of the objects chosen randomly from the selected theme will be spawned. While the object is placed the user will hear to a sound specific to the theme that notified that the object is placed. The user has to pick the spawned object and select the category that the object belongs to as instructed by the steer.
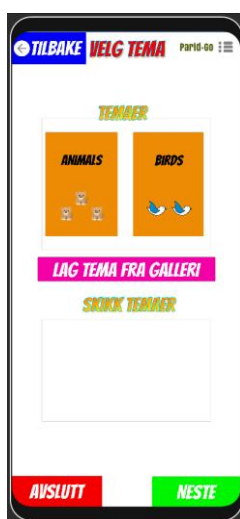

First Screen of Parid-GO

5.2 Theme Page

The theme page has two sections. The first section has the existing themes where all the predefined themes are contained in the scroll functionality. Each theme button in this section has the name of the theme and icons that denotes the difficulty levels available for that theme.

Theme Page

The images of existing theme button are shown below. A button with one icon indicates that only easy level is available for that theme. A button with two icons includes both easy and medium level. Similarly, a button with three icons includes all the difficulty levels.

The second section has the user defined themes contained in a scroll. Every time the parent/care giver saves a customized theme, a button for that theme is created and appended to the scroll in this section.
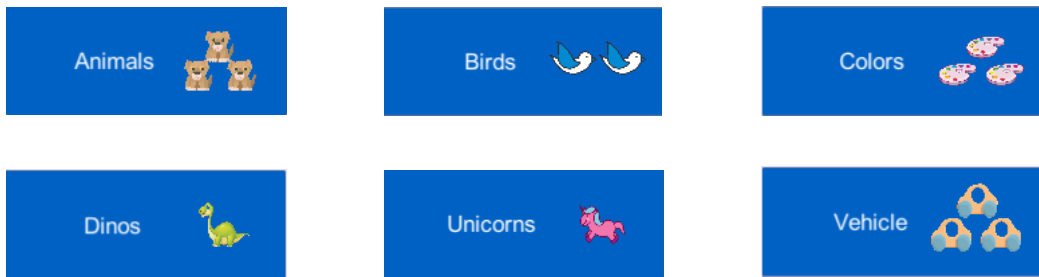
Theme Buttons Initial Design

5.3 Categorization

Categorization part is included in the game to provide a bit of cognitive thinking for the user group to boost their interest towards the game. The idea is to have categorization for medium and hard level to increase the level of difficulty. Categorization is not necessary in the easy level which only involves picking up the objects and placing them into their house. In the medium and hard level, as soon the object is picked the steer gives them task to find which house the object belongs to. The difference between the medium and hard level is that medium level has two categories whereas hard level has 3 categories.

Choose Difficulty Page

5.4 Steer, Objects, Houses

5.4.1 Steer

Every theme has a steer specific to the theme. Steers are objects that directs the user about the scenario. During the entire game, they are friend-like characters. While the user selects the theme, the steer is also fixed. Every theme has a direction that is unique to it. The user is guided through the situation via steers, which are objects. During the entire game, they are likeable characters. The steer is fixed at the same time that the user chooses the theme.

From that moment the steer aids by displaying instructions to the user and reads the message out loud. The steer uses cloud like object to display the texts. In the initial design we used steers that were larger. After usability test, based on the feedback that the user might get confused between the steer and object spawned, the size of the steer was made smaller. The image below shows how it looks now.

The list of steers against each theme is shown in the table below.

| Animal	Bird	Color	Dino	Unicorn	Vehicle

5.4.2 Objects

We were studying what kind of objects to be used in this game. The previous project included 3D objects for the content. However, number of objects required for dynamic content is more which has two limitations, the application might end up requiring large storage space and 3D models are expensive. This led to choosing of image as objects. We also discussed whether to use Portable Network Graphics files or Scalable Vector Graphics files(2000). Images of PNG file format were chosen as unity supports this format easily and they are also available free for university at www.mostphotos.com.

For every specific theme to merge with the real-world environment, images where collected, modified, and converted to sprites (graphical images) to be used in the game scenario.

5.4.3 Houses

House are place where the objects belong to. The users are asked to choose the house based on the object they pick. Easy level has a default house. Houses play important role in the game when it comes to level of difficulty.
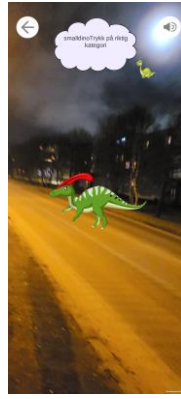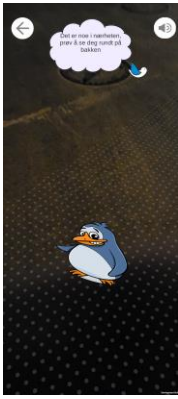
6 Results and Discussion

Sorterius is an impactful game and a great innovation in the field of using technology to assist and motivate people with Intellectual disabilities. Taking Sorterius as a guiding light, Parid-GO accomplished diversities in its game play. Our first problem statement was 'How can we design various modes that could match the interest of users with different severity of intellectual disability?'. Parid-GO attained to solve this problem by implementing different existing modes that are default to the game. These modes are available with different levels of difficulties. Some themes include only easy level whereas others uses both medium and difficult levels. In this way Parid-GO matched the interest of users with different severity of intellectual disabilities.

Theme Page with Interaction

Our second problem statement was 'How can we improve the game application to encourage continued usage?'. The game tried to satisfy this problem in various ways including adding real sounds of the objects that appears which notifies the user that the object is spawned and exploding theme specific objects like particles to cheer the users.
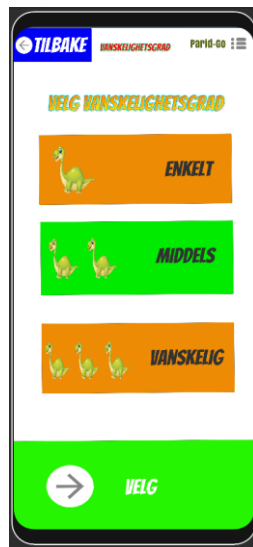
Choose Difficulty Page with Interaction

Visualization is also a critical part for continued usage. The way the colors are involved based on the recommendation, the style of the texts and buttons, combining steers to the theme play, using attractive images together led to a great visualization of the game application. This accomplishes our third problem statement which is 'How can we design the application to make visualization attractive?'.

Finally, our fourth problem statement is 'How can we implement a custom theme option for the supervisor of the user to append user specific theme materials?'. We tried our best to accomplish this problem. Although, this feature allowed the user to fetch images from the

device to create a user specific theme, the objects could not be spawned. This was a real challenge that had to be faced with during the development of Parid-GO. However, it was a great learning experience as a proof of concept. A comparison between Parid-GO and Sorterius is given in the following table.

Parid-GO	Sorterius
Includes Multiple Default Themes such as Animal, Bird, Color, Dino, Unicorn, Vehicle.	Includes single theme which is collecting garbage.
Visualization is made better and attractable for people with ID at the same time by following the suggested colors for the target group	Visualization is basic and plain. Also follows the suggested colors for the target group
Tried to include Custom theme by an administrator (Cares/Parent)	Does not have the feature to add custom theme.
Makes theme specific sound while objects appear and cheers while the objects are grabbed	Does not include theme specific sound when object appears.
Steers are specific to the theme, and they appear as a guide throughout the game session	Mascot appears as the guide
Uses only 2D images and no 3D objects involved. This helps in faster rendering of the game.	Uses both 2D and 3D objects
Captivates the users with intuitive visualisation and images	Mostly uses the mascot and garbage objects
Number of objects in themes button resembles the levels of difficulties available for that theme	Single theme is available

Comparison between Parid-GO and Sorterius

7 Conclusion

Because AR overlays virtual visuals on real-world photos in real time, it is advantageous. In a pleasant and interesting way, it enables pupils to see, hear, and touch the information. Aside from that, by analysing the data of AR users, developers may be able to design individualised lesson plans that cater to the needs of individual user and give them access to the most effective methods of motivation.

Many augmented reality (AR) applications are widely available, affordable, and convenient to use. Due to their interactivity and enjoyment, they also have the potential to help user retain enthusiasm far better than regular games. A study from Nigeria published in January 2020 found that AR gadgets improve user's performance and retention regardless of their gender.

Overall, all studies showed at least some favourable impacts on user with various needs, and depending on the circumstance, it enhanced their involvement in the Physical activities by utilising the advantages of the AR.

The customization and personalisation factor in "Parid-GO" varies person to person based on the level of their ID. The main concern of the app is to make a change to their sedentary lifestyle and interact with the app without any hesitation or involving external push from their care takers or guardians. This creates a limitless bond between the user and "Parid-GO". Another crucial concern is the mental health of the user that should not be interrupted or distracted while in the game mode. To focus on this concern, "Parid-GO" was built in a way not to make any false noise or annoying notifications.

The customisation and personalisation changes differ accordingly every person to person with different intellectual skilled person, The app is mainly designed to make the physical activity to be mainly concerned and to pull out from the loneliness and making them to interact without any hesitations and contributing the involvement without the force of the care takers or guardians. Which mainly creates an understanding with limitless bond between them. When

we speak about the intellectual disabilities the thing which is mainly to be concerned is mental health which should not disturbed at any point. Like the way" Parid-GO" was built in the way not to create any false alarms and annoying notification manner. Even though it helps if the person went missing or the lost the path, since the app works with always on GPS, which helps to keep an eye on them and to track easily.

Instead of getting misguided on the social media, which called as current generation trend leads to do dangerous activity such as selfie, reels, adult plus content. It mainly focuses them to work physical s wells as improves their daily IQ level to keep them on focused and make them to get routine in at least a certain amount of progress in their activity.

Day to day we can visualise in our daily surroundings, certain users who can't even speak and identify the household items, which makes a change for them, when they were subjected to get familiar with this.

It will also make them to be close with a personalised character, which they choose and name with their own Augmented reality [AR] experience. Which also makes to do other activity such as draw and paint their character.

Still in the world there are more, and rare intellectual disabilities were not found, and it is far away to reach. Based on this, "Parid-GO" will be upgraded with more customised features, along with that, there will be a MOU [Mutual of Understanding] in future, which will connect with medical world like paediatrician, physiotherapist, mental therapist, disabilities specialist to know and develop the app more and more.

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