Design Recommendations for Developing Health Information System Applications for use by Persons with Mild Intellectual and Developmental Disabilities

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PhD Abstract

Introduction- Persons with IDD remain among the most vulnerable members of society and frequently face numerous health information barriers. Persons with IDD experience unequal access to health information with limited resources or opportunities to exercise their rights and make informed choices. Within the healthcare environment, persons with IDD experience a disparity of health services availability compared with others, resulting in increased morbidity, poorer health status and reduced participation in health promotion activities. While the ultimate goal of providing health information is to inform, enable understanding, support decision-making and provide knowledge about taking action, there is a lack of evidence of how persons with IDD use Health Information Systems (HIS). There is a need for HIS development guidelines to make the HIS applications for persons with IDD.

Research Aim and Objectives - This research aims to identify the factors of successful HIS applications for persons with mild IDD. To achieve the aim of this research, the following objectives were set:

- To develop a set of design recommendations for designing and developing HIS applications for persons with mild IDD.
- To provide designers/developers of HIS applications for persons with mild IDD with design recommendations in an easy-to-understand format.

Methodology – A mixed methods study was undertaken incorporating five phases. The first phase identified the problem through initial literature review and a systematic review around research concerning HIS and persons with IDD. In this phase, the research gap was identified, and the first version of design recommendations was created, DR-HIS-IDD (Design Recommendations for the Development of HIS for the intellectual and developmental disabilities population). In the second phase, the researcher interviewed and observed the participants, and this phase produced the second version of DR-HIS-IDD. In this phase, an essential factor was discovered, which is "Gamification". Little evidence exists involving persons with mild IDD having gamification-based interventions to use HIS applications. There is a knowledge gap as to what design recommendations are needed for the development of gamification solutions for persons with mild IDD. In the third phase, there were two steps: the researcher conducted a literature review on gamification for persons with IDD, and the researcher conducted an analysis of mobile apps based on user reviews. This phase produced

the third version of recommendations. In the fourth phase, validation and evaluation, the researcher developed a mobile app and released it to the Apple store (iOS) platform, and the researcher analysed user reviews. The researcher also interviewed experts to validate the recommendations; experts were from one or more of the following areas: software development, user experience, health informatics, health care providers. This resulted in the final version of DR-HIS-IDD. Phases 1-4 resulted in a more comprehensive collection of recommendations than was previously available. In the fifth phase, the researcher transformed the definitive list of recommendations into design patterns.

Results - From the literature, initial findings indicated that persons with IDD are faced with many challenges and factors when using HIS applications, including knowledge/training, HIS content, accessibility issues, usability issues and engagement. These initial factors were further derived and synthesised into four factors after interviewing and observing persons with IDD. These factors were usability, accessibility, content, and gamification. An initial set of 230 design recommendations was derived and synthesised into 46 design recommendations. Then these recommendations transformed into design patterns that should be followed by the developers of HIS applications. The evidence from this research revealed that usability, accessibility are closely related aspects in developing HIS for everyone. Gamification and Content can make HIS specifically appropriate for persons with mild IDD. Thus, this research developed guidance, presented in the form of design patterns for developing HIS for persons with mild IDD.

Conclusions - This research produced an empirically derived, evaluated, and validated set of design recommendations for HIS development for persons with mild IDD. These recommendations will support software developers in developing HIS for persons with mild IDD. The unique contribution to knowledge is that these recommendations provide a structured approach to address the challenges faced by persons with IDD when use HIS applications. The software development industry needs to pay attention to the specific usability, accessibility, content, and gamification needs of persons with IDD when developing HIS applications.

This technical report presents the complete empirically derived, evaluated, and validated set of design recommendations for HIS development for persons with mild IDD, as presented in Chapter 7 of the PhD thesis.

Design recommendations for HIS development for persons with mild Intellectual and Developmental Disability

"Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, In such a way that you can use this solution a million times over, without ever doing it the same way twice."

-Christopher Alexander, A Pattern Language, 1977

1. Introduction

The term design patterns are used to describe documented practical answers to design problems (Alexander, 1977) forms of rules for performance improvement, referred by certain associated circumstances and documented in a consistent manner. Design patterns are a toolkit of solutions to common problems in software design. Each pattern is like a blueprint that can customise to solve a particular design problem faced by software developers in developing HIS applications.

Undertaking this research, 46 recommendations were established. These were transformed into design patterns. The structure of design patterns and reasons to include each specific attribute is explained in Table 1.

Design Pattern Name	For ease of referencing to a problem/solution pairing.			
Factor	Identifies the type with which pattern belongs - Usability,			
	Accessibility, Content or Gamification.			
Sub-factor	States the sub-factor to which the pattern belongs.			
Problem	Describes the problem and when to apply the pattern. It explains			
	the situation and its context.			
Solution	Presents the instruction and how to address the problem.			
Evidence resources	Identifies the source of the pattern - research literature or primary			
	research.			

Table 1: Structure of Design Patterns



Figure 1: Research Process - Phase 5

2. The Pattern Groupings

The factors and sub-factors presented in this chapter organised into four distinct groupings; the first two (Usability & Accessibility), which are closely related aspects in creating HIS applications that work for everyone. The other two sets (Gamification & Content) make HIS applications specifically appropriable to use by persons with mild IDD. There are 46 design patterns as shown in figure 2.



Figure 2: Design Patterns

3. Usability

Usability is the extent to which users can use a system's functionality with effectiveness, efficiency, and satisfaction to achieve specific goals. Employing user/human-centred design processes helps ensure that products or systems are highly usable and meet users' needs. These processes emphasise and utilise the user perspective throughout design, development, and test (WAI, 2020). Despite the widespread usage of technology, HIS applications have unique usability challenges, even amongst persons who do not have any cognitive impairment. These include small screen size, different display resolutions, device orientation changes, and an array of the touchscreen (Williams and Shekhar, 2019).

i. Usable

When building HIS applications for persons with mild IDD, they need to be simple and easy to use. HIS applications should be designed in a way that is familiar and easy to understand. Usable is how to make users interact with the product and its features (Dekelver et al., 2015, W3C, 2020a). Recommendations are shown in Figure 3, followed by the design patterns.

Usable
Allow a direct log in, reducing the need
to make an account or password.
Avoid making HIS applications too
complex.
Put text on a bright background, so the
contrast will be clear for users (avoid
dark coloured backgrounds)
Make HIS application pages attractive.
Make it easy to find help and support
channels for users.
Provide accurate information and avoid
too many descriptions of HIS
applications.
Avoid using too many steps in HIS
applications.
Minimise the choices available for
users.
Make the display keyboard layout fit
appropriately on the screen.
Avoid making many clicks for users.
Make a keyboard with word prediction
for users.

Figure 3: Usable

Allow a direct log in, reducing the need to make an account or password.		
Factor	Usability	
Sub-factor	Usable	
Problem	Cognitive impairment is one of the common issues related to	
	persons with IDD, making it difficult for them to remember	
	complex things. In the context of technology, passwords are	
	troublesome for persons with IDD [1-2].	
Solution	Make HIS applications accessible without the need for a	
	password. Allow a direct log in with no need to have users create	
	an account. Remove the need for a password to access HIS apps.	
	Use biometrics, fingerprint or facial recognition, or a text	
	message to a phone number as alternate access technique [1-2].	
Evidence	[1] W3C (World Wide Web Consortium). Cognitive	
Resources	Accessibility User Research. Available online: https:	
	//w3c.github.io/coga/user-research/#intellectual disability	
	(accessed on 10 September 2019).	
	[2] Mobile app reviewers "I installed this app and every time I go	
	to login it says to activate my account through the email, but it	
	never sent me the email and I keep clicking resend confirmation	
	code; my email is spelled correctly I've uninstalled and	
	reinstalled the app countless times. that's really a bummer	
	because I was hoping this could be a useful tool, but it's been	
	more of a pain than anything.", "Disappointed! Skips over	
	creating an account and straight to log in! I can't log in without	
	an account! Very frustrating, I have 2 kids who would benefit	
	from this application. Very disappointed,".	

Avoid making HIS applications too complex.		
Factor	Usability	
Sub-factor	Usable	
Problem	Too much text, graphics, and other context information can lead	
	to cognitive overload, anxiety, and a loss of focus [1,2].	
Solution	Do not fill HIS applications with too much information to ensure	
	that users see it clearly. Include e simple words, brief sentences,	
	text blocks, clear graphics, and simple video [1-2].	
Evidence	[1] Karreman, J., Van Der Geest, T. and Buursink, E. Accessible	
Resources	website content guidelines for users with intellectual disabilities.	
	Journal of Applied Research in Intellectual Disabilities, 2007.	
	[2] Mobile app reviewers "It is too compact. Does not even use	
	the whole of my screen. I cannot adjust the size of the screen, nor	
	rotate it. Therefore, it is useless to me as I cannot read any part	
	of it. Very disappointed". "It is very difficult to understand how	
	to get this set up and working for me, so I don't think the people	
	I work with who have disabilities will have much hope. Very hard	
	to figure out how to set up".	

Put text on a bright background, so the contrast will be clear for users (avoid		
dark coloured backgrounds)		
Factor	Usability	
Sub-factor	Usable	
Problem	Persons with mild IDD may have an impaired perception of	
	colour, thus requiring specific colour schemes to assist in the	
	comprehension of text.	
Solution	Ensure the text is displayed in colour (yellow is often a standard	
	background colour). Also, background and foreground colour	
	combinations must provide enough contrast [1-2].	
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design	
Resources	Requirements for a Digital Aid to Support Adults with Mild	
	Learning Disabilities During Clinical Consultations: Qualitative	

Study	with	Experts.	JMIR	rehabilitation	and	assistive
technol	ogies,	2019.				
[2] Mo	bile ap	p reviewei	rs "I do	wish there were	colou	ur choices
for the	text an	d backgrou	ınd".			

Make HIS application pages attractive.		
Factor	Usability	
Sub-factor	Usable	
Problem	It is crucial that persons with mild IDD are shown attractive	
	pages when using HIS applications; they might not focus on the	
	information for a longer time if the pages are not desirable.	
Solution	Make the product pages attractive by, for example, allowing the	
	users to choose a preferred photo from the gallery or internet as	
	their background. The visual aesthetics of the HIS application	
	must be appealing and simple to translate in order to make it	
	attractive to users [1-2].	
Evidence	[1] Williams, P. and S. Shekhar, Persons with learning	
Resources	disabilities and smartphones: Testing the usability of a touch-	
	screen interface. Education Sciences, 2019.	
	[2] Mobile app reviewers, "Initial pages of the app are attractive,	
	makes users go further and explore, but, as it follows the	
	questions, it becomes a bit tedious.".	

Make it easy to find help and support channels for users.		
Factor	Usability	
Sub-factor	Usable	
Problem	Persons with mild IDD need considerable help and support when using technology.	
Solution	Make it easy and available to find help and support in the HIS applications for users. Help features provided by the product must be clear and understandable. Information about how to use it and configure it must be made available as well as a list of	

	possible error events the application may notify and frequently		
	asked questions [1-2].		
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design		
Resources	Requirements for a Digital Aid to Support Adults with Mild		
	Learning Disabilities During Clinical Consultations: Qualitative		
	Study with Experts. JMIR rehabilitation and assistive		
	technologies, 2019.		
	[2] Mobile app reviewers "This appears to be a good start to a		
	functional app, but not everything is there yet. What I found		
	problematic: - App crashed when I tried to upload a user profile		
	pic - the Contact Support and Contact Privacy Officer links don't		
	work".		

Provide accurate information and avoid too many descriptions of HIS		
	applications.	
Factor	Usability	
Sub-factor	Usable	
Problem	Literacy skills for persons with mild IDD include the capacity to	
	read and understand simple text-up to three sentences or one	
	paragraph, follow simple instructions and one section, follow	
	simple instructions, and use a simple list [1-2].	
Solution	HIS applications should include support documentation for any	
	product or service. The documentation must provide clear	
	instructions in easy language and structure, with a demo for users	
	so that they can watch how to use it and access it. [1-2].	
Evidence	[1] Williams, P. and S. Shekhar, Persons with learning	
Resources	disabilities and smartphones: Testing the usability of a touch-	
	screen interface. Education Sciences, 2019.	
	[2] Mobile app reviewers, "Way too much writing and	
	descriptions that aren't read allowable. A lot of the Irish accents	
	are too thick for children to understand who Irish aren't. Not child	
	accessible enough. Way too many complicated unnecessary	
	fantasy information".	

Avoid using too many steps in HIS applications.		
Factor	Usability	
Sub-factor	Usable	
Problem	Persons with mild IDD find it easy to be distracted by many	
	actions or steps when dealing with websites or mobile apps.	
	This is associated with cognitive impairment in working	
	memory related to IDD [1-2].	
Solution	Reduce the number of steps involved in mobile apps or websites	
	to allow the task to be achieved successfully. The number of	
	click uses throughout the apps should be reduced to a minimum	
	to aid users who have limited attention [1-2]	
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design	
Resources	Requirements for a Digital Aid to Support Adults with Mild	
	Learning Disabilities During Clinical Consultations: Qualitative	
	Study with Experts. JMIR rehabilitation and assistive	
	technologies, 2019.	
	[2] Mobile app reviewer "It would be better to reduce the steps	
	to complete the task. So, it would be much better with few steps	
	in the process - as few clicks in the process as possible."	

Minimise the choices available for users.		
Factor	Usability	
Sub-factor	Usable	
Problem	Experts agreed that developers should reduce the number of	
	selections available within the mobile app for persons with IDD	
	to ease users' cognitive load [1-3].	
Solution	Have simple navigation, with just a few choices, rather than	
	navigation with lots of options. Try not to exceed 4 choices	
	given to users [1-3].	
Evidence	[1] Williams, P. and S. Shekhar, Persons with learning	
Resources	disabilities and smartphones: Testing the usability of a touch-	
	screen interface. Education Sciences, 2019.	
	[2] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design	
	Requirements for a Digital Aid to Support Adults with Mild	
	Learning Disabilities During Clinical Consultations: Qualitative	
	Study with Experts. JMIR rehabilitation and assistive	
	technologies, 2019.	
	[3] Mobile app reviewer "This is an awesome app that is	
	customisable for each user even down to two choices at a time."	

Make the display keyboard layout fit appropriately on the screen.	
Factor	Usability
Sub-factor	Usable
Problem	Persons with mild IDD may find it difficult to continuously
	click on a key. They frequently confuse the right/left mouse
	buttons [1-3]. If the display keyboard layout does not fit on
	screen, users might be easily distracted by other activities
	available on the screen.
Solution	Always display only one activity on-screen [1-3]. Always make
	uppercase letter display in the on-screen keyboard

Evidence	[1] Williams, P. and S. Shekhar, Persons with learning
Resources	disabilities and smartphones: Testing the usability of a touch-
	screen interface. Education Sciences, 2019.
	[2] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design
	Requirements for a Digital Aid to Support Adults with Mild
	Learning Disabilities During Clinical Consultations: Qualitative
	Study with Experts. JMIR rehabilitation and assistive
	technologies, 2019.
	[3] Mobile app reviewer "Reading part of the app is good.
	Would be better if it auto advanced to a new word when you get
	an answer correct. On my phone the writing part is unusable -
	displays a keyboard layout but the letters are about 4 times too
	big to fit on the keys so all I can see is the corner of each letter
	(the rest is cut off). Also, the word that is supposed to be spelled
	is too big for the box it goes in so cannot be read (can only see
	the top 30% of each letter)".

Avoid making many clicks for users	
Factor	Usability
Sub-factor	Usable
Problem	Persons with mild IDD find clicking difficult, and continuously
	clicking on a key can make them easily confused [1-3].
Solution	Make the next step available instead of letting the users keep
	clicking the object. The number of clicks used throughout HIS
	applications such as websites or apps should be reduced to a
	minimum for users who have limited attention spans [1-3].
Evidence	[1] Williams, P. and Nicholas, D. Testing the usability of
Resources	information technology applications with learners with special
	educational needs (SEN). Journal of Research in Special
	Educational Needs, 2006.
	[2] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design
	Requirements for a Digital Aid to Support Adults with Mild
	Learning Disabilities During Clinical Consultations: Qualitative

Stu	udy with Experts. JMIR rehabilitation and assistive
tec	chnologies, 2019.
[3]	Mobile app reviewer "App won't let me past the choose of
av	atar step. Not recognising double clicks and there is no next
bu	tton available.)".

Make a keyboard with word prediction for users.	
Factor	Usability
Sub-factor	Usable
Problem	Word prediction is an assistive feature for writing that suggests
	words as a user type. Use advanced word prediction options
	which can be beneficial for persons with mild IDD who struggle
	with writing. [1-2].
Solution	Build a simple text word prediction keyboard for users.
Evidence	[1] Interview Extract – "I did not learn typing on the computer
Resources	in school, so I did not start typing on my iPhone until I use
	WhatsApp. I like how my iPhone on keyboard gives me the
	word prediction that I intended to type, which is great features",
	"He hardly writes a word of Panadol. When he clicks search."
	[2] Mobile app reviewer "Would it be Possible to Make a
	Keyboard with Word Prediction for Persons who are Writers
	but Need Speech Feedback.?"

ii. Available

To make HIS applications available to persons with mild IDD, they should be available in the market at a reasonable price, working in different operating systems such as IOS or Android, and Windows. The product's title should also be short in text and simple to let users get in quickly. Persons with IDD tend to be reluctant to read long texts. Therefore, their perception of low self-efficacy concerning the comprehension of complex texts may have led them to avoid reading actively and, at best, become passive readers (Fajardo et al., 2014). Recommendations are shown in Figure 4, followed by the design patterns.

Available

Make the HIS application name (Title) clear and reflect its content.

Make the HIS applications work well on different operating systems, e.g., Android, iOS, and Windows.

Do not include words 'therapy' and 'disability' in the title of HIS applications

Figure 4: Available

Make the HIS application name (Title) clear and reflect its content.	
Factor	Usability
Sub-factor	Available
Problem	Persons with mild IDD tend to be reluctant to read long texts
	because text length is an external difficulty cue. Therefore, their
	perception of low self-efficacy concerning the comprehension of
	complex texts may have led them to avoid reading actively and,
	at best, become passive readers. [1]
Solution	Titles of the website or mobile app should be short and
	straightforward [1-3].
Evidence	[1] Fajardo, I., Ávila, V., Ferrer, A., Tavares, G., Gómez, M. and
Resources	Hernández, A. Easy-to-read texts for students with intellectual
	disability: linguistic factors affecting comprehension. Journal of
	applied research in intellectual disabilities, 2014.
	[2] Dekelver, J., Kultsova, M., Shabalina, O., Borblik, J.,
	Pidoprigora, A. and Romanenko, R., 2015. Design of mobile
	applications for people with intellectual disabilities. Creativity In
	Intelligent Technologies And Data Science, Cit&Ds 2015.
	[3] Mobile app reviewers "It opens, shows the name and closes
	down right away Downloaded thinking it's something to teach
	empathy to persons with autism, I'm already autistic, don't
	actually need an app like that, especially if it doesn't work. I

wouldn't be surprised if it was just a design that got awards and
got forgotten". "It's not doing any good for the families of autistic
children but quite opposite, very misleading app's name as well"

Make the HIS applications work well on different operating systems, e.g.,		
	Android, iOS, and Windows.	
Factor	Usability	
Sub-factor	Available	
Problem	Google's Android, Apple's iOS, and Windows are operating systems used primarily in mobile technology devices, such as smartphones and tablets. Users might not be able to get access to all of these platforms simultaneously. Therefore, it is better for software developers to develop their product so that can work on all operation systems.	
Solution	Enable HIS applications to run smoothly in different operating systems such as IOS, Android, and Window [1].	
Evidence	[1] Mobile app reviewers "love the app but please make it	
Resources	available in iOS 8". "Great app, inquiry about iOS Hello Jeroen!!! Love the app, but I have friends who want it as well but	
	run-on iOS devices". "Backed up in the cloud At School my son has an iPad but at home we have Android tablets. It's nice that we can access his boards from any device."	

Do not include words 'therapy' and 'disability' in the title of HIS applications	
Factor	Usability
Sub-factor	Available
Problem	Negative attitudes and behaviours hurt children and adults with
	disabilities, leading to negative consequences such as low self-
	esteem and reduced participation. Persons who feel harassed
	because of their disability sometimes avoid going to places,
	changing their routines, or even moving from their homes [1,2].

Solution	Avoid using disability phrases in HIS applications (e.g.,
	Intellectual disability, Learning disability, Developmental
	disability, Mental retardation, Mental deficiency, Autism or
	Down syndrome [1.2].
Evidence	[1] World Health Organization. Chapter 1: Understanding
Resources	disability. World report on disability. 2011:1-7.
	[2] Mobile app reviewers "In my professional opinion, you
	should not include words therapy and autistic in the name of the
	app. It's not doing any good for the families of autistic children
	but quite opposite, very misleading app's name as well".

iii. Supporting Independence

Digital Technology is on the rise as a tool to promote independence in many areas, including mobility, hearing and vision, communication, independent living, and computer use. Existing and new technology can be used to empower persons with IDD to manage their health issues. HIS applications can be one strategy to support persons with IDD who are transitioning to a state of independence to handle medications on their own (Haymes et al., 2015, Salgado et al., 2018). Independence recommendations are shown in Figure 5, followed by design patterns.

Independence

Make the users feel the ownership of the HIS applications.

Give users the option to adjust the level to suit their age/ ability.

Figure 5: Independence

Make the users feel the ownership of the HIS applications.	
Factor	Usability
Sub-factor	Independence
Problem	Using computers in therapy with IDD persons increases their
	willingness to engage in individual therapy because interactive
	techniques promote ownership and motivation to change. [1-3]

Solution	Allow users to feel a sense of product ownership. Software
	developers should make users to feel that they own this app, so
	that they are engaged and motivated to use it. Allow features to
	achieve improved greater independence for persons with IDD
	[1.3]
Evidence	[1] Vereenooghe, L., Gega, L. and Langdon, P.E. Intellectual
Resources	disability and computers in therapy: views of service users and
	clinical psychologists. Cyberpsychology, 2017.
	[2] Morgan, M.F. and Moni, K.B. Literacy: Meeting the
	challenge of limited literacy resources for adolescents and adults
	with intellectual disabilities. British Journal of Special
	Education, 2008.
	[3] Mobile app reviewers "My son loves this app! We work
	together on lessons daily, but he can also play independently".

Give users the option to adjust the level to suit their age/ ability.			
Factor	Usability		
Sub-factor	Independence		
Problem	Persons with IDD experience difficulties when performing		
	actions that required specific skills, but their motivation to		
	complete the tasks does not reduce.		
Solution	The user should have the option to adjust the level of capability		
	that meet their needs and should be customisable to suit an		
	individual's needs, too [1,2].		
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design		
Resources	Requirements for a Digital Aid to Support Adults with Mi		
Learning Disabilities During Clinical Consultations: Qua			
	Study with Experts. JMIR rehabilitation and assistive		
	technologies, 2019.		
	[2] Mobile app reviewers "Awesome app for kids with autism,		
	my 2 1/2-year-old son has autism & he loves this app. He is very		
	fussy when it comes to apps but loves this one & it's good that		
	you can adjust the level to suit their age and ability.".		

iv. Useful

The educational experts described digital technology devices such as tablet application as useful because persons with IDD could gain new technical skills. It also increases the persons' ability to focus. Some experts further indicated that HIS applications could help develop many skills besides completing such a task independently, increasing self-confidence (Yeni et al., 2019). Useful recommendations are shown in Figure 6, followed by the design patterns.

Useful

Allow a person with a verbal disability to communicate by translating pictures into text messages.

HIS applications should take the user further to gain more skills.

Figure 6: Useful

Allow a person with a verbal disability to communicate by translating pictures					
	into text messages.				
Factor	Usability				
Sub-factor	Useful				
Problem	Pictograms incorporate a visual layer to transmit information. A				
	large proportion of persons with IDD require this type of				
	communication layer. Experts agreed that the combination of				
	pictures, text, and speech is crucial to the patient's understanding				
	of the symptoms displayed [1-2]				
Solution	To ease the understanding of text-based communications,				
	software developers should include pictures that provide vital				
	information and repeat the information provided in text [2-3].				
Evidence	[1] Kennedy, H., Evans, S. and Thomas, S. Can the web be made				
Resources	accessible for persons with intellectual disabilities? The				
	Information Society, 2011.				
	[2] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design				
	Requirements for a Digital Aid to Support Adults with Mild				
	Learning Disabilities During Clinical Consultations: Qualitative				

Study	with	Experts.	JMIR	rehabilitation	and	assistive
technol	ogies,	2019.				
[3] Mo	bile ap	p reviewer	rs "I hav	e severe anxiety	and c	lepression
disorde	rs, and	in the mic	lst of a p	anic attack, I ne	eed a c	uick non-
verbal	way to	communic	ate with	someone trying	to help	o (because
of sense	ory ove	erload and	inability	to speak), and t	his is	a discreet,
easy to	use ap	p that is a	n immer	nse help to me".	"Alth	ough you
have to	work	in the lang	guages p	rovided in the e	editing	mode, in
the use	r mode	can work	in any l	anguage if you	can fii	nd a voice
in your	langua	age and tra	nslate th	e text in the pict	togran	ıs."

HIS applications should take the user further to gain more skills.			
Factor	Usability		
Sub-factor	Useful		
Problem	Daily living skills are particularly crucial for persons with IDD		
	because they directly affect the development of capabilities such		
	as autonomy and self-determination. Also, completing daily		
	living skills can lead to greater independence and increased		
	initiative, encouraging different abilities [1].		
Solution	Allow the users to go further in HIS applications to learn daily		
	living skills such as play skills, reading skills, writing skills and		
	healthy eating habits [1-2].		
Evidence	[1] Yeni, S., K. Cagiltay, and N. Karasu, Usability investigation		
Resources	of an educational mobile application for individuals with		
	intellectual disabilities. Universal Access in the Inform		
Society, 2019.			
	[2] Mobile app reviewers ". My nephew was able to click the		
pictures he saw, and the voice said the word. I am hoping the			
	continues using this tool I know it is designed to take him much		
	further with his skills". "Initial pages of the app are attracti		
	makes users go further and explore, but, as it follows the		
	questions, it becomes a bit tedious."		

v. Reliable

To make HIS applications reliable, they need to be trusted by users. Most activities to improve software reliability focus on how software developers can predict and prevent defects (Wood, 2003). HIS applications must establish trust and present themselves as reliable to turn visitors into customers. Persons' techniques to determine trustworthiness on the web/mobile app have remained stable throughout the years, even with changing design trends. Reliable recommendations are shown in Figure 7, followed by the design patterns.

Reliable

HIS applications should inform users that their information is safe and confidential.

HIS applications should inform users of the purpose of data collection.

Figure 7: Reliable

HIS applications should inform users that their information is safe and					
	confidential.				
Factor	Usability				
Sub-factor	Reliable				
Problem	Clinicians highlighted potential confidentiality threats as they				
	believed that persons with ID would be more vulnerable to				
	confidentiality breaches by the technology-mediated exchange of				
	information. Software developers have the utmost responsibility				
	to maintain users' confidentiality and to ensure that no harm may				
	come because of releasing their private information [1].				
Solution	Allow users to give authorization to whoever accesses their				
	information.				
Evidence	[1] Vereenooghe, L., Gega, L. and Langdon, P.E. Intellectual				
Resources	disability and computers in therapy: Views of service users and				
	clinical psychologists. Cyberpsychology, 2017.				
	[2] Mobile app reviewers, "Because I denied the permissions to				
	access all the stuff on my phone, the app is rendered useless. can't				
	use it AT ALL just because I don't want it accessing my calls or				

contacts or whatever it wanted. make apps that don't require
invasion privacy!".

HIS applications should inform users of the purpose of data collection.		
Factor	Usability	
Sub-factor	Reliable	
Problem	Many software applications capture and send potentially sensitive personal information to cloud servers. Users, on the other hand, have little idea of why their data is being collected. Persons with mild IDD need to be made aware of compute threats to privacy and of confidentiality issues arising from	
	information sharing via a computer [1].	
Solution	Make the users aware of sharing information and let the users know their information uses [2].	
Evidence	[1] Vereenooghe, L., Gega, L. and Langdon, P.E. Intellectual	
Resources	 disability and computers in therapy: Views of service users and clinical psychologists. Cyberpsychology, 2017. [2] Mobile app reviewers "Not helpful for language development Not evidence based. May be engaging for the child as a game, but when you go read the research provided, this is non-existent. I'd be wary of giving away diagnostic info and date of birth as requested. Isn't this highly unethical? Just wondering what the data collected will be used for.". 	

b. Accessibility

Accessibility addresses discriminatory aspects related to equivalent user experience for persons with disabilities. Web accessibility means that persons with disabilities can equally perceive, understand, navigate, and interact with websites and tools. It also means that they can contribute equally without barriers (WAI, 2016).

i. Understandable

Persons with mild IDD might have other difficulties understanding health information (Williams and Nicholas, 2006). Support for such persons with mild IDD may include use clear and simple language, make the word pronunciation clear and understandable, make simple sentences and bullets, use a simple language of health education on video. Understandable design recommendations are shown in Figure 8, followed by design patterns.

Understandable

Use clear and straightforward language.

Make the word pronunciation clear and avoid using complicated terminology.

Make simple sentences and bullet points.

Use a simple language of health education on video, so the users can easily understand.

Figure 8: Understandable

Use clear and straightforward language.				
Factor	Accessibility			
Sub-factor	Understandable			
Problem	Persons with IDD are at an increased risk of not understanding the language used to describe concepts; thus, HIS applications must use alternative formats to represent the information efficiently [1].			
Solution	Reduce the number of words and make the sentences as short as possible. The language should be in a plain format to ensure the reader understands as quickly, easily, and thoroughly as possible. [1-2]			
Evidence [1] Dekelver, J., Kultsova, M., Shabalina, O., Borblik,				
Resources	Pidoprigora, A. and Romanenko, R., . Design of mobile applications for people with intellectual disabilities. Creativity In Intelligent Technologies And Data Science, Cit&Ds 2015.			

[2] Karreman, J., Van Der Geest, T. and Buursink, E. Accessible
website content guidelines for users with intellectual disabilities.
Journal of Applied Research in Intellectual Disabilities, 2007.
[2] Mobile app reviewer, "I changed the language age into
Spanish, and the pronunciation is terrible, far away from what it
should be. The robotised voice pronounces the words with the
English accent and should be read in English, not Spanish."
"Using this app was a turning point for my autistic son. He started
to speak some simple words. I cannot explain my feelings. Thank
you so much"

Make the word pronunciation clear and avoid using complicated terminology.		
Factor	Accessibility	
Sub-factor	Understandable	
Problem	The most common error that persons with IDD faced while using	
	HIS applications is that words were mispronounced, which	
	resulted in reading and listening to non-existing words [1-3].	
Solution	Accents, letters, and diacritics that are required to phonetically	
	read the words should be included in the word pronunciation.	
	[1,3].	
Evidence	[1] Karreman, J., Van Der Geest, T. and Buursink, E. Accessible	
Resources	website content guidelines for users with intellectual disabilities.	
	Journal of Applied Research in Intellectual Disabilities, 2007.	
	[2] Williams, P. and S. Shekhar, Persons with learning	
	disabilities and smartphones: Testing the usability of a touch-	
	screen interface. Education Sciences, 2019.	
	[3] Mobile app reviewer "I changed the language into Spanish	
	and the pronunciation is terrible, far away from what it should be.	
	The robotized voice pronounces the words with English accent	
	and as should be read in English, not in Spanish.", "The stor	
	phrases work well. I have had to correct the pronunciation of	
	common words.", "Definitely good for the price. You can do a	

	lot with this app. But for a person trying to learn to talk, this is
	not the best app. Words are not pronounced correctly."

	Make simple sentences and bullet points.			
Factor	Accessibility			
Sub-factor	Understandable			
Problem	Instructions are difficult to read for people with IDD unless they			
	are written in simple, easy-to-understand language. Text that has			
	been simplified is required. A summary of a paragraph with a			
	well-known symbol, brief bullet points, and a clear picture or			
	graphic of what is necessary are the best options for users [1-3].			
Solution	Make a few short bullet points. Each bullet point should begin			
	with an icon/image that corresponds to the information contained			
	within that point. [1,3].			
Evidence	[1] Williams, P. and S. Shekhar, Persons with learning			
Resources disabilities and smartphones: Testing the usability of				
	screen interface. Education Sciences, 2019.			
	[2] Martin, G.E., Klusek, J., Estigarribia, B. and Roberts, J.E.			
	Language characteristics of individuals with Down syndrome.			
	Topics in language disorders, 2009.			
	[3] Mobile app reviewer "Couldn't find the simple sentence			
	structure or promised.", "Using this app was a turning point for			
	my autistic son. He started to speak some simple words. I cannot			
	explain my feelings. Thank you so much!!!!", "Hard to read since			
	the format isn't the best. But all of the information is right on			
	point and very helpful and informative."			

Use a simple language of health education on video, so the users can easily		
	understand.	
Factor	Accessibility	
Sub-factor	Understandable	
Problem	As health care focuses beyond disease management, including	
	education, prevention, and promotion, professionals need to take	
	advantage of this opportunity by exploring ways to expand health	
	directives for persons with IDD [1].	
Solution	Incorporate a short video of health promotion instead of using	
	text.	
Evidence	[1] Cardell, B. Reframing health promotion for persons with	
Resources	intellectual disabilities. Global qualitative nursing research,	
	2015.	
	[2] Interview Snippet- "I have watched some video on YouTube	
	or Twitter about health topics." "I follow some Doctors on	
	Twitter, and sometimes they uploaded a video about the disease,	
	and I watched it. Also, they upload some pictures of a disease	
	symptoms."	

ii. Perceivable

To make HIS applications perceivable to users, they must be able to perceive the information being presented (it can't be invisible to all of their senses) (WAI, 2019). Instructions for operating controls or understanding content do not rely on a single purpose. This may prove inaccessible to persons with IDD related to that sense or a device that does not support that sense. For example, *click the round button to continue and start the task*, that click could also be combined by sound to make it hearable and visible to the user. The button should be clearly labelled to evidence that it is the button that the user needs to press. Perceivable design recommendations are shown in Figure 9, followed by design patterns.

Perceivable

Notify the users when the device works and when the task starts.

Make the sound loud and hearable for users.

Make the search engine icon clear, so the users can easily find it.

Make Multimedia sources such as video and pictures available for users.

Figure 9: Perceivable

Notify the users when the device works and when the task starts.	
Factor	Accessibility
Sub-factor	Perceivable
Problem	Persons with IDD are heterogeneous in nature and may not
	respond to information in the same manner as others; for
	example, 40% have hearing impairments and can find it difficult
	to understand data transmitted via sound [1-2].
Solution	The digital technology devices should notify the user that it
	works, or that the task is started by enabling the vibration mode
	[1-2]
Evidence	[1] Dekelver, J., Kultsova, M., Shabalina, O., Borblik, J.,
Resources	Pidoprigora, A. and Romanenko, R. Design of mobile
	applications for people with intellectual disabilities. Creativity In
	Intelligent Technologies And Data Science, Cit&Ds 2015.
	[2] Mobile app reviewers "I'm trying it for the first time. I'm
	hoping this app can really help me stay on track with my personal
	daily goals, as I have profound executive functioning deficits. I
	missed my first notifications because I didn't have my vibration
	on. I'd like to see an upgrade that allows it to make alarm sounds
	or verbal reminders to at least check your app". "Do NOT sign
	up for this. Besides that, it doesn't even work. Maybe it's better
	if you have the watch to go with it, but otherwise, its seriously

useless, doesn't give you notifications to start the tasks you set
up".

Make the sound loud and hearable for users.	
Factor	Accessibility
Sub-factor	Perceivable
Problem	Some persons with IDD might have a hearing impairment and
	need extra support by technology to make sound hearable [1,2].
Solution	Use concrete and literal words. Use tangible language and
	examples that refer to items or events that users can see, hear, or
	touch as often as possible. Also, make the entry of character
	(typing or clicking) hearable [1-2].
Evidence	[1] Patel, D.R., Greydanus, D.E., Omar, H.A. and Merrick, J. eds.
Resources	Neurodevelopmental disabilities: clinical care for children and
	young adults. Springer Science & Business Media, 2011.
	[2] Mobile app reviewers "Not customisable Cant select sound of
	alarm and the alarm is so quick to finish that a child busy doing
	tasks would most likely not hear it.". "I have auditory processing
	disorder and can't hear in situations with background noise. this
	app is so helpful in navigating those situations."

Make the search engine icon clear, so the users can easily find it.	
Factor	Accessibility
Sub-factor	Perceivable
Problem	Persons with IDD who have significant visual impairments may
	require objects to be increased in size to best suit their needs [1-
	4].
Solution	Make search engine icons more noticeable and easier to find,
	which helps users quickly find it. People with IDD think in
	pictures. Pictures are their first language, and words are their
	second. Individuals with IDD can better digest information when

	they look at pictures or words to help them envision knowledge
	since, they are concrete, literal, visual thinkers [1-4].
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design
Resources	Requirements for a Digital Aid to Support Adults with Mild
	Learning Disabilities During Clinical Consultations: Qualitative
	Study with Experts. JMIR rehabilitation and assistive
	technologies, 2019.
	[2] Williams, P. and S. Shekhar, Persons with learning
	disabilities and smartphones: Testing the usability of a touch-
	screen interface. Education Sciences, 2019.
	[3] Interview Snippet- "I couldn't find a search engine icon on
	the first page of the apps because I want to search for the smoking
	effect."
	[4] Mobile app reviewers "would like to be able to edit the search
	items' names, other than that it is a perfect app, handicapped
	daughter is learning it now".

Make Mult	Make Multimedia sources such as video and pictures available for users.	
Factor	Accessibility	
Sub-factor	Perceivable	
Problem	It is essential that persons with mild IDD need excited about accessing HIS applications; otherwise, they might not focus attention over a more extended time. To understand ideas, people with IDD require visuals, diagrams, or video clips (more than a lot of words) [1-2].	
Solution	Provide non-text multimedia content, such as images and video [1-3].	
Evidence	[1] Williams, P. and S. Shekhar, Persons with learning	
Resources	 disabilities and smartphones: Testing the usability of a touch-screen interface. Education Sciences, 2019. [2] Interview Snippet- "I always deal with video material when I am accessing my smartphone." 	

[3] Mobile app reviewers, "Initial pages of the app are attractive,
makes users go further and explore, but, as it follows the
questions, it becomes a bit tedious.".

iii. Operable

To make HIS applications operable, users should successfully use user-interactive components such as buttons, navigation aids, and controls. User interface components and navigation must be operable (WAI, 2019). This entails detecting an interface control visually and then clicking, tapping, or swiping it for persons with mild IDD. Users will be able to operate and control the interface by utilizing a computer keyboard or voice commands. Operable design recommendations are shown in Figure 10, followed by the design patterns.

Operable

Make it easier for users to operate functionality through various inputs beyond the keyboard.

Make the loading pages in HIS applications very fast.

Figure 10: Operable

Make it easier for users to operate functionality through various inputs	
beyond the keyboard.	
Factor	Accessibility
Sub-factor	Operable
Problem	Persons with IDD sometimes face difficulty in using information technology, including an inability to use the mouse or other input methods (small screen sizes may still be problematic) [1].
Solution	Ensure users can easily switch between different modes of input when interacting with digital content, including touchscreen, keyboard or voice commands [1-3].
Evidence	[1] Williams, P. and S. Shekhar, Persons with learning
Resources	disabilities and smartphones: Testing the usability of a touch- screen interface. Education Sciences, 2019. 9(4): p. 263.

[2] Dekelver, J., Kultsova, M., Shabalina, O., Borblik, J.,
Pidoprigora, A. and Romanenko, R. Design of mobile
applications for people with intellectual disabilities. Creativity In
Intelligent Technologies And Data Science, Cit&Ds 2015.
[3] Mobile app reviewers, "I find this app to be phenomenal for
my kiddos. This sentence is for the editor, it would be great to
add a large erase or delete button just like the large play button
option. It would make the easy sentence touch to erase & build
another sentence."

Make the loading pages in HIS applications very fast.	
Factor	Accessibility
Sub-factor	Operable
Problem	Persons with IDD are heterogeneous in nature and may not
	respond to information in the same manner as other persons do.
	Taking time to load applications could be problematic for persons
	with IDD because of various reasons, including cognitive
	impairments and short attention spans. [1].
Solution	Make sure the loading pages in HIS applications go fast and not
	crashing [1-2].
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design
Resources	Requirements for a Digital Aid to Support Adults with Mild
	Learning Disabilities During Clinical Consultations: Qualitative
	Study with Experts. JMIR rehabilitation and assistive
	technologies, 2019.
	[2] Mobile app reviewers "I am finding it very difficult to load,
	it takes a long time. I can't retrieve messages or see updates very
	well. It's running and loading frequently. Can this be fixed?".
	"Great concept but freezes too much, causing my son to freak
	out. He plays it on his tablet and when he tries to open a game it
	just shows a plain white screen and there's not even an option to
	go back. You have to exit the whole app and reload it all over
	again to get back to the game screen which takes a while and most

of the time still just opens games as a white screen with nothing
on it."

iv. Robust

To make HIS applications robust for use by persons with mild IDD, they need to avoid errors. Content must be robust enough to be interpreted reliably by a wide variety of user agents. A robust product can be one that doesn't break easily. Thus, an operating system in which any individual application can fail without disturbing the operating system or other applications can be said.

Robust

Incorporate a feature of a splash screen by using an image during the loading process.

Avoid crashes and freezes during the execution of functionality of HIS applications.

Never convey information by colour alone. Ensure sufficient contrast so that it is easier to distinguish items, both visual and auditory.

Figure 11: Robust

Incorporate a feature of a splash screen by using an image during the loading		
process.		
Factor	Accessibility	
Sub-factor	Robust	
Problem	All experts agreed that the amount of information presented to persons with IDD should be reduced to ease users' cognitive load, so developers should know that [1-2].	
Solution	Use a splash screen in the loading process, so that it can clearly be visible while the page is loading. After the content is finished loading and there is no further movement, the icon is removed. The splash screen, also known as the start screen, is the initial	

	screen a user sees when they open the app and remains visible	
	while it loads. [1,2].	
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design	
Resources	Requirements for a Digital Aid to Support Adults with Mild	
	Learning Disabilities During Clinical Consultations: Qualitative	
	Study with Experts. JMIR rehabilitation and assistive	
	technologies, 2019.	
	[2] Mobile app reviewers: "Awesome idea and very useful. Great	
	idea. I only wish you could have more than one splash as I have	
	two disorders that affect speech. And separate screens would be	
	easier than putting both options on one.". "My only problem is	
	that there is very little room for text, and my phone is quite large,	
	so the text comes up significantly larger than normal on the	
	splash screen. Could there possibly be a text size changer added	
	to the settings?" "Extremely useful! Changing the splash page is	
	easy, the UI is simple and effective, and it allows communication	
	when talking isn't an option. even if you don't use it for yourself,	
	this app could be a lifesaver to those with autism, asthma, panic	
	attacks, trach tubes, stuttering, hearing/speech loss, or other	
	conditions that make verbal communication difficult, especially	
	in an emergency.", "I love this app. I use the customizable splash	
	screen to instruct strangers on how to handle seizures when I feel	
	one coming on and become nonverbal. Really makes me feel	
	safer."	

Avoid crashes and freezes during the execution of functionality of HIS	
applications.	
Factor	Accessibility
Sub-factor	Robust
Problem	Crashes in HIS applications considered a serious accessibility barrier for persons with IDD [1].
Solution	Improve overall stability to prevent HIS applications fromcrashing. Gently ask the users before they start working on HIS

	apps to close other applications, so that it can free system
	memory in the device which may resolve the issue [1].
Evidence	[1] Mobile app reviewers, "This appears to be a good start to a
Resources	functional app, but not everything is there yet. What I found
	problematic: - App crashed when I tried to upload a user profile
	pic" "Best ABA app by far, especially for younger kids. It does
	crash a lot though, hope that'll get sorted out soon. A lot of
	glitches lately. I have to restart my phone because nothing
	works." "Don't get beyond start image on my Nexus 7. It just
	freezes there Update: It is a Nexus 7 2nd gen. What happens is
	that the app freezes at the Green starting image (the logo), and
	nothing happens. No visible crash or anything. It just stops."

Never convey information by colour alone. Ensure sufficient contrast so that it		
is easier to distinguish items, both visual and auditory.		
Factor	Accessibility	
Sub-factor	Robust	
Problem	Experts revealed that many persons with IDD have an impaired	
	perception of colour and may require specific colour schemes to	
	assist in reading text [1].	
Solution	Ensure the text is displayed in colour (yellow is often a standard	
	background colour). Also, background and foreground colour	
	combinations must provide enough contrast [1-2].	
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design	
Resources	Requirements for a Digital Aid to Support Adults with Mild	
	Learning Disabilities During Clinical Consultations: Qualitative	
	Study with Experts. JMIR rehabilitation and assistive	
	technologies, 2019.	
	[2] Mobile app reviewers, "I do wish there were colour choices	
	for the text and background". "It's really good. Would it be	
	possible for an option to make the text bigger or different bubble	
	colour? My partner is sight impaired and can't see it very well."	
	"Amazing this is going to help so much when I'm in public	

	situations and persons think I'm just being rude by not talking! I
	do wish there were colour choices for the text and background
	(as well as an option to hide the switch person button if auto is
	turned on) but even without that it's an amazing app"

c. Content

i. General Content

As users with language impairment, learning disability and memory impairment, they want the language to be clear and easy for them to understand the content. To make the content of HIS applications understandable by persons with mild IDD, it needs to be simple and easy to recognise. The content of HIS applications should be designed in a way that is familiar and easy to understand. General Content design recommendations is shown in Figure 12, followed by the design patterns.

General Content

Incorporate a feature that makes it easy to get human help and give feedback.

Make the results of any search by the user to be video or pictures first.

Keep the personal information of persons with IDD safe and assure privacy.

Figure	12:	General	Content
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Incorporate a feature that makes it easy to get human help and give feedback.		
Factor	Content	
Sub-factor	General content	
Problem	If users have difficulty sending feedback, software developers will not know if they can use the content or when problem are experienced [1-3].	
Solution	Incorporate a feature that makes it easy to get human help and give feedback through the HIS applications. This could be done	

	by implementing a feature as simple as adding a button such as
	Help, User Voice, or Support that allow users to communicate
	with a help team, provide feedback, and report bugs and other
	issues [1-3].
Evidence	[1] Karreman, J., Van Der Geest, T. and Buursink, E. Accessible
Resources	website content guidelines for users with intellectual disabilities.
	Journal of Applied Research in Intellectual Disabilities, 2007.
	[2] Salgado, T.M., Fedrigon, A., Omichinski, D.R., Meade, M.A.
	and Farris, K.B. Identifying medication management smartphone
	app features suitable for young adults with developmental
	disabilities: Delphi consensus study. JMIR mHealth and uHealth,
	2018.
	[3] Mobile app reviewers "excellent. it is easy to talk to persons
	and help others going through the same stuff you are. features
	make it easy to offer support even if you don't know what to say".

Make the results of any search by the user to be video or pictures first.		
Factor	Content	
Sub-factor	General content	
Problem	Persons with IDD prefer that the information should be presented	
	in an appropriate format by proposing the use of avatars and	
	videos to deliver such content. Users show more interest in	
	mobile apps or websites that contain video clips [1-3].	
Solution	Incorporate a feature that makes the searches result in a video or	
	picture first by filtering the search engine. [1-3].	
Evidence	[1] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design	
Resources	Requirements for a Digital Aid to Support Adults with Mild	
	Learning Disabilities During Clinical Consultations: Qualitative	
	Study with Experts. JMIR rehabilitation and assistive	
	technologies, 2019.	
	[2] Mobile app reviewers "Amazing app. Can't explain how	
	helpful and refreshing the videos are.", "Great Autism App for	
	Young Children! The App has some great videos that implement	

research backed design.", "My daughter uses this app to say what
she wants to eat by clicking on the picture.", "Great effort and
awesome app with simple pictures. Easy to understand."
[3] Interview Snippet "I like to watch a video instead of
reading long text".

Keep the personal information of persons with IDD safe and assure privacy.	
Factor	Content
Sub-factor	General content
Problem	Persons with IDD concerned about their privacy and safety
	online. They want software applications to have built-in
	mechanisms to alert regarding spam [1-3].
Solution	Incorporate privacy and safety regulations within HIS
	applications. The feature should make the users aware of the
	dangers of sharing personal information online and need
	assurance of privacy and safety [1-3].
Evidence	[1] Vereenooghe L, Gega L, Langdon PE. Intellectual disability
Resources	and computers in therapy: views of service users and clinical
	psychologists. Cyberpsychology, 2017.
	[2] Williams, P. and S. Shekhar, Persons with learning
	disabilities and smartphones: Testing the usability of a touch-
	screen interface. Education Sciences, 2019.
	[3] Mobile app reviewers, "I can't use it at all just because I don't
	want it accessing my calls or contacts or whatever it wanted.
	make apps that don't require invasion privacy!".

d. Gamification

Gamification can provide ideal strategies for health promotion, prevention, and selfmanagement of chronic conditions. Gamification is defined as the use of game design elements in non-game contexts (Deterding et al., 2011, Lister et al., 2014). According to researchers, the current trends in digital games can offer opportunities for disease prevention and health promotion in physical and mental health. Gamification components have been used to improve health promotion effectiveness, and there are some excellent research works on the use of gamification to promote physical activity (Turner et al., 2016, Marston and Hall, 2016). Gamification is a powerful resource to increase motivation and engage participants, thus favouring the teaching-learning process or training for specific situations.

i. Graphical User Interface

A graphical user interface (GUI) is an interface through which users interact with electronic devices such as computers, hand-held devices and other appliances. This interface uses icons, menus and other visual indicators (graphics) representations to display information and related user controls, unlike text-based interfaces, where data and commands are written in text. GUI representations are manipulated by a pointing device such as a mouse, trackball, stylus, or a finger on a touch screen (Martinez, 2011). The recommendation of GUI is shown in Figure 13, followed by the design patterns.

GUI

Avoid the use of small objects in the game.

Allow users to control the speed at which they move through the game.

The game should offer a varying range of activities to minimize fatigue or boredom.

Include no objects that are believed to cause seizures, such as flashing elements or elements with specific spatial frequencies.

Enable a fixed game display screen as a means to prevent users from resizing it unintentionally.

Allow users to use their picture in the virtual avatar/character.

Show the time display clearly on screen for the users.

Figure 13: GUI

	Avoid the use of small objects in the game.
Factor	Gamification
Sub-factor	GUI
Problem	Serious games' primary objective is not pure entertainment but
	passing knowledge to the users. Typically, they unfold in an
	environment that is a simulation of the natural world, where the
	player must solve one or more problems. Small design elements
	that rely on interpretation are also confusing, and users may not
	understand the hierarchy [1,2].
Solution	Increase the size of small objects and accompanying applications,
	such as virtual keyboards, physical buttons, and target areas [1-
	2].
Evidence	[1] Tomé RM, Pereira JM, Oliveira M. Using serious games for
Resources	cognitive disabilities. In International Conference on Serious
	Games Development and Applications, Springer, Cham, 2014
	[2] Mobile app reviewer "Great app but needs work. This app is
	such a great idea and I have found wonderful support among the
	members of my autism team. The most recent update even fixed
	some minor annoyances. However, you still cannot edit a
	comment after you post it, and the box for viewing a comment as
	you type it is so tiny that it is easy to miss any mistakes you might
	have made. Please make the box for viewing comments before
	posting larger, and allow users to edit comments after posting,
	even if they appear on another user's original post."

Allow users t	Allow users to control the speed at which they move through the game.		
Factor	Gamification		
Sub-factor	GUI		
Problem	Experts agreed that software developers should reduce the number of choices available in HIS applications for persons with IDD to ease cognitive load [1-3].		

Solution	Incorporate a feature that help users to choose how fast they want
	to play the game since users with learning difficulties can be
	terribly slow in their performance and responding [1-3].
Evidence	[1] Seale J, Garcia-Carrisoza H, Rix J, Sheehy K, Hayhoe S. A
Resources	proposal for a unified framework for the design of technologies
	for persons with learning difficulties. Technology and Disability.
	2018.
	[2] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design
	Requirements for a Digital Aid to Support Adults with Mild
	Learning Disabilities During Clinical Consultations: Qualitative
	Study with Experts. JMIR rehabilitation and assistive
	technologies, 2019.
	[3] Mobile app reviewer "This is an awesome app that is
	customizable for each user even down to two choices at a time."

The game should offer a varying range of activities to minimize fatigue or				
	boredom.			
Factor	Gamification			
Sub-factor	GUI			
Problem	It is also possible to change the actions each object offers, such			
	as the ball rolling or bouncing and the swing swinging. The			
	variety of functionalities of each object increases the user's			
	attention and prevents him/her from getting bored. [1-3].			
Solution	Game activities and pacing should be varied to avoid fatigue or			
	boredom, for example, players should not be penalized			
	repeatedly for the same failure [1-3].			
Evidence	[1] Tomé RM, Pereira JM, Oliveira M. Using serious games for			
Resources	cognitive disabilities. In International Conference on Serious			
	Games Development and Applications, Springer, Cham, 2014.			
	[2] Gibson, R.C., MM. Bouamrane, and M. Dunlop, Design			
	Requirements for a Digital Aid to Support Adults with Mild			
	Learning Disabilities During Clinical Consultations: Qualitative			

Study wit	h Experts.	JMIR	rehabilitation	and	assistive
technologie	s, 2019.				
[3] Mobile	app review	er- "Usef	ful for all child	ren who	o exhibit
autistic or r	ormal devel	opment.	I believe that an	applica	ation that
deserves m	uch more th	an the co	ost. The games a	are desi	igned for
the develop	ment of chil	dren and	prevent them fr	om bei	ng bored
while playi	ng." "It's am	azing tha	t they update the	e app ar	nd games
so frequer	tly. My li	ttle here	o never gets	bored.'	" "Very
Disappoint	ed Started of	f okay bu	t then they got b	ored af	iter a few
days? This	app would s	uffice if i	t weren't so bug	gy. No	thing but
problems w	vith it resett	ing itself	f. Not intuitive	setup a	and very
limited voc	abulary root	s. Could l	nave potential if	it were	to get an
overhaul."					

Include no objects that are believed to cause seizures, such as flashing elements			
	or elements with specific spatial frequencies.		
Factor	Gamification		
Sub-factor	GUI		
Problem	Person with IDD have a difficult time splitting and switching		
	their attention and are easily distracted. They also have trouble		
	separating their attention to stay focused on the activity, and they		
	lack impulse control [1].		
Solution	To minimize the cognitive load that persons with IDD have,		
	software developers should create simple-layout stages that		
	consist of a few elements and contain the least animation		
	elements possible [1,2].		
Evidence	[1] Buchnat, M. and Wojciechowska, A. Online education of		
Resources	students with mild intellectual disability and autism spectrum		
	disorder during the COVID-19 pandemic. Interdisciplinary		
	Context of Special Pedagogy, 2020.		
	[2] Mobile app reviewer- "Ads are distracting Is there a way to		
	pay for a version with no ads? The flashing lights are distracting".		
	"The concept seems very good, and the layout is easy. My son,		

however, said the voice that plays with the flashcards is "sad."
But it is nice to have the cards and recording option".

Enable a fixed	game display screen as a means to prevent users from resizing it
	unintentionally.
Factor	Gamification
Sub-factor	GUI
Problem	The motor and visual decline associated with IDD makes it
	difficult for persons with IDD to distinguish and use small
	components on the screen effectively. Users with learning and
	cognitive difficulties are more likely to make errors. This can
	involve inadvertently inputting incorrect information or touching
	the wrong button. [1-2].
Solution	Assist the user in recognizing and correcting form errors. Allow
	users to return to a previous state if they mistakenly touch a
	button. Always make the display of the game fit properly on
	screen with no other activities or elements display on screen. [1-
	2].
Evidence	[1] Tomé RM, Pereira JM, Oliveira M. Using serious games for
Resources	cognitive disabilities. In International Conference on Serious
	Games Development and Applications, Springer, Cham, 2014.
	[2] Mobile app reviewer- "Doesn't actually pin the app to prevent
	him from getting into other apps. All my one-year-old has to do
	is tap the screen and the drag bar comes down which covers the
	whole screen so he can get out of the game". "Educational and
	fun I watched my grandchildren play with it and noticed how they
	were practicing their letters, numbers, shapes, colours etc. Made
	me laugh when I saw their little fingers jump across the screen
	catching most, if not all bubbles. What a fun way to learn!!!
	Highly recommend it."

Allow users to use their picture in the virtual avatar/character.	
Factor	Gamification
Sub-factor	GUI
Problem	It was found that many users did not identify themselves with the
	game. This is a problem since they may not be able to play as
	they wouldn't understand what is going on in the game [1].
Solution	Let the users to use their own pictures to better understand and
	enjoy the game [1-2].
Evidence	[1] Tomé RM, Pereira JM, Oliveira M. Using serious games for
Resources	cognitive disabilities. In International Conference on Serious
	Games Development and Applications, Springer, Cham. 2014.
	[2] Mobile app reviewers- "Amazing! My son who has autism is
	enjoying this. The best part is you can personalize it by taking
	your own pictures. Wow!". "Very nice This is a great application.
	It is very customizable in that you can use your own pics. My son
	enjoys the push as you go."

Sho	w the time display clearly on screen for the users.
Factor	Gamification
Sub-factor	GUI
Problem	Persons with IDD do not always like completing tasks under time
	pressure [1-2].
Solution	Make the time display shows clearly on screen for the users by
	inserting a digital clock widget. Allow for the provision extra
	time and do not suddenly quit from the game [1-2]
Evidence	[1] Seale J, Garcia-Carrisoza H, Rix J, Sheehy K, Hayhoe S. A
Resources	proposal for a unified framework for the design of technologies
	for persons with learning difficulties. Technology and Disability.
	2018.
	[2] Mobile app reviewer- "What an excellent visual aide for our
	little one when waiting for time to pass! It keeps her focus, and
	she loves the sound effects when the time is passing.",

	"Inaccurate countdown time Ann doesn't give you the option of
	indecurate countdown time ripp doesn't give you the option of
	choosing exact amount of time to elapse, even in premium. You
	can only choose from their set intervals. Therefore, you can't
	count down exactly to an event"

ii. Reward

Reward systems can be viewed as player motivators or as compromises for easing disappointment. In modern video games, reward systems also provide social meaning within and outside of games. To our knowledge, there is plenty of information and multiple theories in the psychology literature on optimal experiences, intrinsically motivating environments, sense of accomplishment, satisfaction, choice, and other concepts that reward system designers can take advantage of. Reward mechanisms provide a sense of fun by fostering intrinsically rewarding experience (Wang and Sun, 2011). Design recommendations of reward is shown in Figure 14, followed by the design patterns.

Reward
Provide a value gift for users that should depend on the user's performance (based on the game's time).
The game should let the user commit errors.
Provide a reward playtime at the end of the game.

Figure 14: Reward

Provide a value gift for users that should depend on the user's performance (based on the game's time).		
Sub-factor	Reward	
Problem	There is a lack of appropriate games for persons with IDD and a	
	lack of rewarding players, hence the need to develop new and	
	innovative games that can truly capture the users and help them	
	overcome (some) of their needs. [1-3]	

Solution	Provide a value gift for users that should depend on the user's
	performance (based on the time spent on the game) e.g., symbolic
	gift, score act, stars. [1,3].
Evidence	[1] Saleh MS, Aljaam JM, Karime A, Elsaddik A. Learning
Resources	games for children with intellectual challenges. International
	Conference on Information Technology Based Higher Education
	and Training (ITHET), (IEEE.), 2012.
	[2] Tomé RM, Pereira JM, Oliveira M. Using serious games for
	cognitive disabilities. In International Conference on Serious
	Games Development and Applications, Springer, Cham, 2014
	[3] Mobile app reviewers- "This app has been perfect to get my
	8-year-old daughter moving in the mornings. We went from
	having zero extra time to her finishing her routine with 30 min to
	spare! She loves earning stars and working toward rewards.".

The game should let the user commit an error.		
Factor	Gamification	
Sub-factor	Reward	
Problem	Persons with IDD could learn and develop the best approaches to	
	the problem presented within the game. Consequently, when	
	confronted by the same in a real situation, they have a greater	
	probability of acting accordingly [1-2].	
Solution	The game should let the user commit errors to let them learn from	
	their mistakes. The player should be reimbursed for making the	
	correct actions. This can be achieved by gifting users with things	
	they like, including animations, music, videos, points and objects	
	in the game [1-3].	
Evidence	[1] Tomé RM, Pereira JM, Oliveira M. Using serious games for	
Resources	cognitive disabilities. In International Conference on Serious	
	Games Development and Applications, Springer, Cham, 2014.	
	[2] Torrente J, Del Blanco Á, Moreno-Ger P, Fernández-Manjón	
	B. Designing serious games for adult students with cognitive	

disabilities. In International Conference on Neural Information Processing, Springer, Berlin, Heidelberg, 2012. [3] Mobile app reviewers "the game is great and really amazing to learn. it would be really great if I get access to the games, I played in the past to learn back the moves I made and the mistakes I missed to see.", "I think it is extremely useful for special needs students. I teach students and I use this application in my class for learning while having fun. The app makes the students make a mistake and learn from their mistakes. I recommend it to all parents to use at home because I am satisfied with the results."

Provide a reward playtime at the end of the game,		
Factor	Gamification	
Sub-factor	Reward	
Problem	In IDD-specific interventions, rewards have been widely employed to reinforce certain behavioral patterns, often delivered shortly after the task is completed. The reward feedback seemed to persons with IDD as the most appropriate because, as shown by research, this kind of feedback is getting easily perceived by users [1-4].	
Solution	Provide a reward playtime at the end of the game. This can be achieved by gifting the user with bonus features, extra points, level upgrade, and hint or tips [1-4].	
Evidence	[1] Tomé RM, Pereira JM, Oliveira M. Using serious games for	
Resources	 cognitive disabilities. In International Conference on Serious Games Development and Applications, Springer, Cham, 2014. [2] Torrente J, Del Blanco Á, Moreno-Ger P, Fernández-Manjón B. Designing serious games for adult students with cognitive disabilities. international Conference on Neural Information Processing, Springer, Berlin, Heidelberg, 2012. [3] Tang JS, Falkmer M, Chen NT, Bölte S, Girdler S. Designing a serious game for youth with ASD: Perspectives from end-users 	

and professionals. Journal of autism and developmental disorders. 2019. [4] Mobile app reviewers "I am an occupational therapist, and this app is amazing how it allows you to choose the progression and also allows for a reward at the end for a play session. Best app I have seen.". "This app has done wonders for our son! He loves it! The reward playtime at the end is a great incentive to keep his attention." "This app has done wonders for our son! He loves it"

4. Summary

This technical report presented the design patterns to help software developers in HIS development for persons with mild IDD, which emerged from research data, described in a pattern structure.

DR-HIS-IDD presents recommendations to support the development of HIS applications, thereby contributing to the established knowledge on Health Informatics. The unique aspect of these design recommendations is that they are empirically derived from the research undertaken in this PhD project. To summarize, these design patterns will serve as a valuable and dependable starting point for practitioners who want to create functional and open HIS applications for persons with mild IDD.

5. References

The complete list of references is available in:

Alshammari, Muneef, Design Recommendations for Developing Health Information System Applications for use by Persons with Mild Intellectual and Developmental Disabilities, PhD Thesis, University of Limerick, 2022